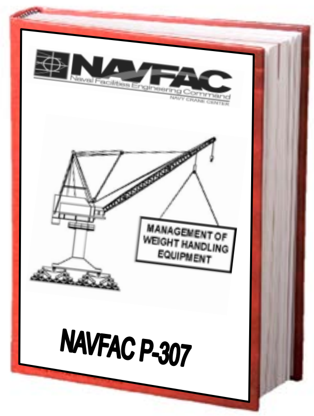
NAVFAC
Naval Facilities Engineering Command
NAVY CRANE CENTER

# Navy Crane Center




# NAVFAC P-307 Training

## CRANE RIGGER

## WEB BASED TRAINING STUDENT GUIDE

## NCC-CR-04

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## INTRODUCTION TO CRANE RIGGER

Welcome to the Crane Rigger course. Crane Rigger is designed to acquaint personnel (such as professional riggers) with Navy requirements for safe lifting and handling operations and provide a knowledge base on which to build upon with on-the-job experience.

The following topics will be discussed during this training:

- NAVFAC P-307
- Complex and Non-Complex Lifts
- Determining Load Weight and Load Weight Distribution
- Sling Angle Stress and D/d Ratio
- Rigging Gear Marking and Record Requirements
- Rigging Gear Inspection, and Test Requirements
- Rigging Gear Use
- Crane Communications, and Crane Team Concept
- Attachment Points
- Pre-Planning and Executing Crane Lifts; and
- Safe Operations

## NAVFAC P-307 TRAINING OVERVIEW


ILT: This module is not needed.

WBT: Review this informational module online.

NOTICE:
NOT ALL OF THE ONSCREEN CONTENT / NARRATION IS CAPTURED IN THIS STUDENT GUIDE; TAKING NOTES MAY BE NECESSARY.

# NOTES

## NAVFAC P-307

### NAVFAC P-307 Purpose

The overall purpose of NAVFAC P-307 is to maintain the level of safety and reliability that was originally built into the equipment, ensure optimum service life, provide uniform standards for weight handling equipment operator licensing, and ensure safe weight handling operations.

Weight Handling Equipment includes both cranes and the rigging gear used for lifting operations.

### NAVFAC P-307 Applicability

NAVFAC P-307 applies to Navy shore activities, including Navy activities on joint bases and bases of other military services and agencies; Naval Construction Forces, including the naval construction training centers, and naval special operating units; and fleet activities and detachments that operate shore based weight handling equipment.

NAVFAC P-307 meets, or exceeds, all OSHA regulations that apply to the operation of cranes.

### NAVFAC P-307 Contents

For an overview of NAVFAC P-307, review this table of contents.

**NAVFAC P-307 Table of Contents**

| Section | Contents |
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| 1 | General Overview |
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| 8 | Licensing Procedures and Documentation |
| 9 | Operator Checks |
| 10 | Operation Safety |
| 11 | Additional Requirements |
| 12 | Investigation and Reporting of Crane and Rigging Gear Accidents |
| 13 | Training and Qualification |
| 14 | Rigging Gear and Miscellaneous Equipment |

### Weight Handling Requirements

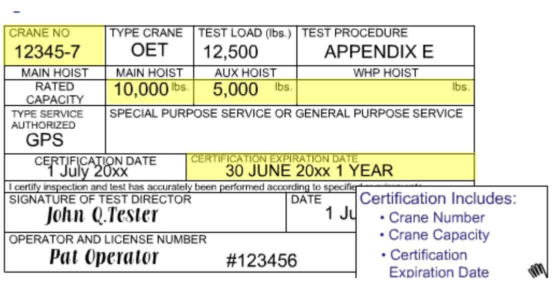
NAVFAC P-307 provides requirements for Weight Handling Equipment including maintenance (repairs and alterations), inspection, test, certification, operations, training, licensing, and rigging gear use.

### WHE Maintenance and Inspection

NAVFAC P-307 provides requirements for documentation of maintenance and inspection, including: types and frequency of inspection; deficiencies to load bearing parts, load controlling parts, and operational safety devices; repairs and alterations made to cranes; and minimum requirements for record keeping retention.

## Certification Posting

The crane identification number, certified capacity and certification expiration date must be posted on or near the crane.




Posting a copy of the actual certification, crane test cards, stickers or signs, are all acceptable methods provided they include the required information.

## NAVFAC P-307 Covered Equipment

NAVFAC P-307 covers category 1, 2, 3, and 4 cranes, as well as rigging gear. Detailed descriptions of the cranes are included in Section 1. Illustrations of individual crane types can be found in Appendix B. Rigging gear is covered in Section 14.

## NAVFAC P-307 Overview Section 1

Section 1 describes cranes and crane-related equipment and lists types of cranes and related equipment used at Naval Shore activities by category.

## Category 1 Cranes

This is a list of category 1 cranes. All category 1 cranes require a license to operate.

## Category 1 Crane Examples

These are examples of Category 1 cranes.

Floating Crane

Hammerhead

Container Cranes

Derrick

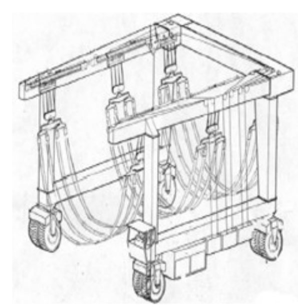
Portal

Mobile

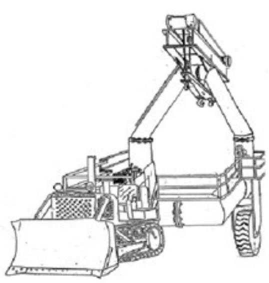
## Mobile Boat Hoist (Straddle Type)

This mobile boat hoist consists of a steel structure of rectangular box sections, supported by four sets of dual wheels capable of straddling and carrying boats.

**Mobile Boat Hoist**



**Mobile Boat Hoist**



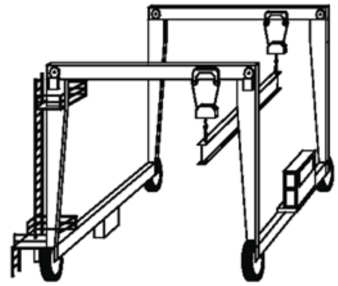
## Mobile Boat Hoist (LCRU)

The landing craft retrieval unit is a type of mobile boat hoist with self-propelled or towed carriers consisting of a wheeled steel structure capable of straddling and carrying boats.

## Rubber Tire Gantry

The rubber tire gantry crane shone is a Cat 1 crane as described in NAVFAC P-307.

**Rubber Tire Gantry Crane**



**Category 2 and Category 3 cranes include:**

- Bridge Cranes
- Rail Mounted Gantry Cranes
- Pillar Jib Cranes
- Wall Canes
- Jib Cranes
- Monorail
- Fixed overhead hoists
  - Manual
  - Powered

Portable hoists are covered in Section 14 of NAVFAC P-307

The activity may, however, treat them as Cat egory 2 or 3 cranes.

## Category 2 and 3 Cranes

This is a list of Category 2 and Category 3 cranes. Portable manual and powered hoists are covered in Section 14 of the NAVFAC P-307. The activity may, however, treat them as Category 2 or 3 cranes.

## Category 2 and 3 Crane Capacities

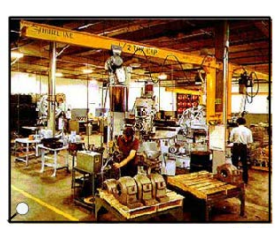
The certified capacity of these cranes determines the category. Category 2 cranes have a certified capacity of 20,000 lbs. and greater. Category 3 cranes are those with a certified capacity of less than 20,000 lbs.

## Category 2 and Category 3 Crane Examples

These are examples of Category 2 and Category 3 Cranes.

Bridge or OET Crane

Pillar Jib

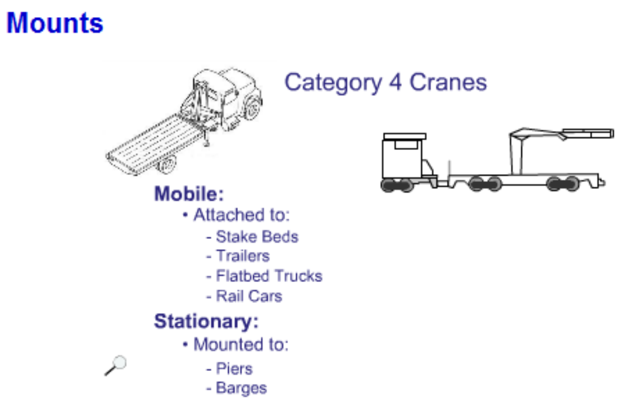


Jib

Trolley Mounted Overhead Hoist

## CATEGORY 4 CRANES

All Category 4 cranes require a licensed operator.

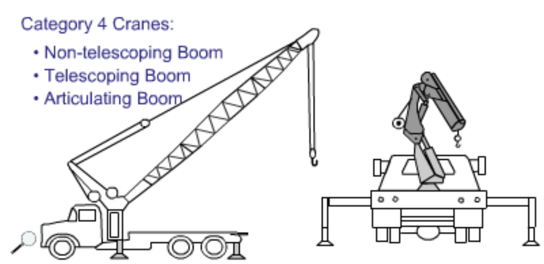




## MOUNTINGS/CONFIGURATIONS

Category 4 cranes may be attached to stake beds, trailers, flatbed trucks, rail cars, or may be stationary mounted on piers, barges, etc.

## CATEGORY 4 CRANES: BOOMS

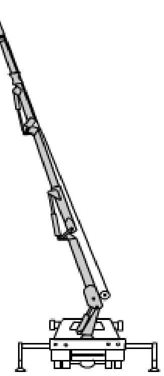
Category 4 Cranes may have a non-telescoping, telescoping, or articulating boom.





## PEDESTAL MOUNTED - CAPACITY

Pedestal mounted commercial boom assembly cranes with less than 2,000 lbs. capacity are considered Category 3 cranes. Capacities greater than 2,000 lbs. are Category 4 cranes and require a licensed operator.



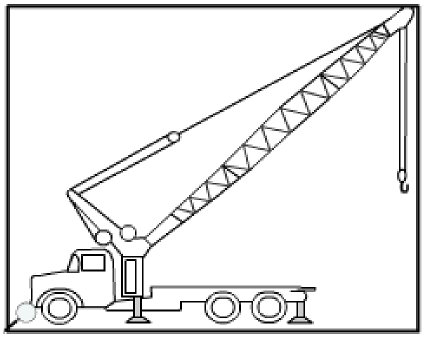
## SPECIAL CONSIDERATIONS

Commercial truck mounted cranes [described in ASME B30.5] and articulating boom cranes [described in ASME B30.22] of all capacities are Category 4 cranes and require a licensed operator - even if the crane is down rated for administrative purposes.

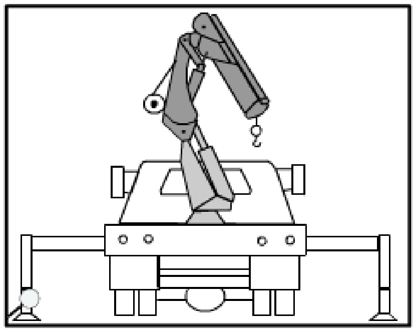
## CATEGORY 4 CRANES: EXAMPLES

These are examples of Category 4 cranes.

Truck Mounted
Commercial Boom Assembly



Non-Telescoping Boom



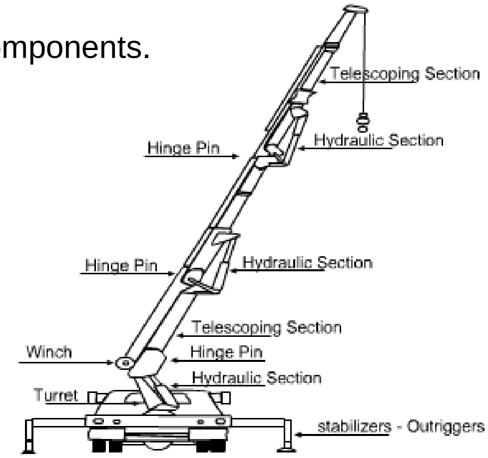
Articulating Boom Crane

Articulating Boom Crane
Truck Mounted

Hydraulic Extendible Boom

## CATEGORY 4 CRANES: COMPONENTS

Using your mouse, explore these Category 4 crane components.




## OPERATOR LICENSING (SECTIONS 6, 7, 8)

NAVFAC P-307 provides uniform standards for crane operator licensing. Cat 1, Cat 2, cab-operated Cat 3, and Cat 4 operators must be trained and licensed according to Sections 6, 7, and 8. Licenses are not required to operate non-cab operated Cat 3 cranes. However, training and a demonstration of ability to operate safely is required.

## CRANE ACCIDENTS

In the event of an accident, activities shall investigate and report the accident in accordance with NAVFAC P-307 Section 12, as well as OPNAV Instructions 5102.1. Crane and Rigging Gear Accident definitions can be found in Section 12.

**Crane Accidents Defined**

A crane accident occurs when any of the elements of the operating envelope fail to perform correctly during operations, including operation during maintenance or testing resulting in the following:

- Personnel Injury or death

  Minor injuries that are inherent in any industrial operation, including strains and repetitive motion related injuries, shall be reported by the normal personnel injury reporting process of the activity in lieu of these requirements.

- Material or equipment damage
- Dropped load
- Derailment
- Two-blocking
- Overload
- Collision including unplanned contact between the load, crane, and/or other objects.

**Rigging Gear Accident Defined**

A rigging gear accident occurs when any of the elements of the operating envelope fails to perform correctly during weight handling operations resulting in the following:

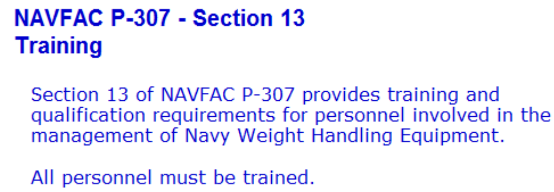
- Personnel injury or death.

  Minor injuries that are inherent in any industrial operation, including strains and repetitive motion related injuries, shall be reported by the normal personnel injury reporting process of the activity in lieu of these requirements.

- Material or equipment damage that requires the damaged item to be repaired because it can no longer perform its intended function.
- Dropped load
- Two-blocking or cranes and powered hoists covered by section 14 (Rigging Gear and Miscellaneous Equipment)
- Overload

## TRAINING

Personnel training requirements are found in section 13 of NAVFAC P-307.





## SECTION 14 – RIGGING GEAR

Section 14 of NAVFAC P-307 provides maintenance, inspection, and test requirements for rigging gear and miscellaneous equipment not covered in sections 2 through 11.

# NOTES

## COMPLEX AND NON-COMPLEX LIFTS

### NON-COMPLEX LIFTS

Non-complex lifts are ordinary in nature, do not require direct supervisory oversight, and are made at the discretion of the rigger in charge.

### COMPLEX LIFTS

Complex lifts have a moderate to high level of risk. Activities are required to identify complex lifts and prepare detailed written procedures for their execution. Procedures may be in the form of standard instructions or detailed procedures specific to a lift.

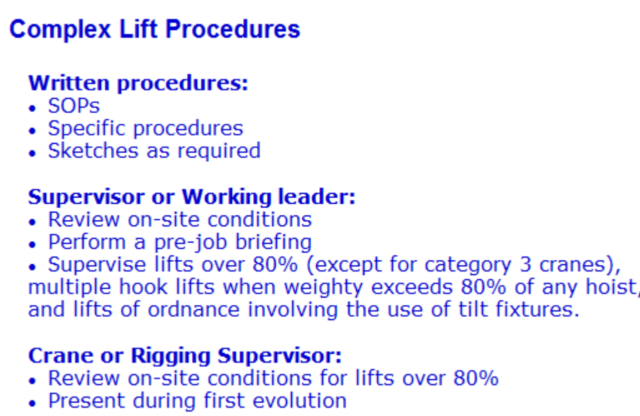
### COMPLEX LIFT CATEGORIES

Complex lifts include:

- hazardous materials
- large and complex geometric shapes
- lifts of personnel
- lifts exceeding 80 percent of the capacity of the crane's hoist and lifts exceeding 50 percent of the hoist capacity for a mobile crane mounted on a barge (Excluded from this rule are lifts with jib cranes, pillar jib cranes, fixed overhead hoists, and monorails, and lifts of test weights during maintenance or testing when directed by a qualified load test director)
- lifts of submerged or partially submerged objects
- multiple crane or multiple hook lifts on the same crane
- lifts of unusually expensive or one-of-a-kind equipment or components
- lifts of constrained or potentially constrained loads (a binding condition); and
- other lifts involving non-routine operations, difficult operations, sensitive equipment, or unusual safety risks.

### SUPERVISOR RESPONSIBILITIES

A supervisor or working leader must review on-site conditions and conduct a pre-job briefing for all complex lifts. A supervisor or working leader must supervise lifts over 80% (except for category 3 cranes), multiple hook lifts when the weight exceeds 80% of any hoist, and lifts of ordnance involving the use of tilt fixtures. If the



lifts are repetitive in nature, supervisors must be present during the first complex lift evolution with each team. Subsequent identical lifts by the same crew may be done under the guidance of the rigger-in-charge.

## Complex Lift Exceptions

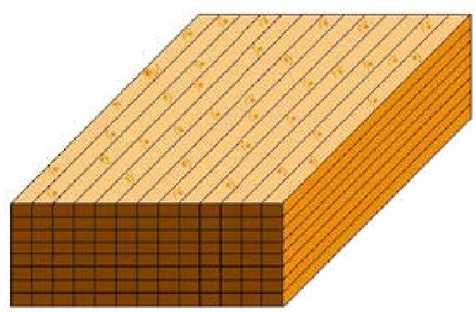
Exceptions to the complex lift requirements include lifts over 80% of capacity made with jib cranes, pillar jib cranes, fixed overhead hoists, and monorail cranes. These cranes are usually smaller capacity cranes used primarily to service only one workstation, machine or area. Lifts of test weights during maintenance or load test are excluded from the complex lift requirements. Ordnance lifts covered by NAVSEA OP 5 in lieu of the NAVFAC P-307 are also excluded; except for lifts using tilt fixtures, lifts where binding may occur, lifts of submerged loads, multiple crane or multiple hook lifts.

## Hazardous Material Lift Requirements

Lifting hazardous materials with a crane is a complex lift. Materials such as oxygen, acetylene, propane or gasoline in bottles, cans or tanks that are properly secured in racks designed for lifting by a crane are excluded.

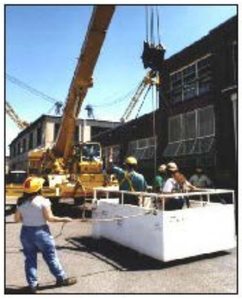
## Complex Geometric Shape Lift Requirements

Complex lifts also include large and complex shapes. For example, objects with large sail area that may be affected by winds, objects with attachment points at different levels requiring different length slings, and odd shaped objects where the center of gravity is difficult to determine.



## PERSONNEL LIFT REQUIREMENTS

Use cranes for lifting personnel only when no safer method is available. Cranes, rigging gear and personnel platforms shall conform to OSHA requirements: 29 CFR Part 1926.1431. The total weight of the loaded personnel platform and rigging shall not exceed 50% of the rated capacity of the hoist. A trial lift with at least the anticipated weight of all personnel and equipment to be lifted shall be performed immediately before placing personnel in the platform. A proof test of 125% of the rated capacity of the platform must be held for 5 minutes. This may be done in conjunction with the trial lift.



## LIFTS OVER 80% CAPACITY

Lifts exceeding 80% of the capacity of the hoist are considered complex lifts. Use a larger capacity hoist if possible to avoid exceeding 80% of capacity.

## MULTIPLE CRANE LIFT REQUIREMENTS

Lifts with two or more cranes are complex lifts. These lifts require special planning, coordination and skill. The weight carried by each crane must be calculated carefully. One signal person must be assigned to direct and control the entire operation.

# NOTES

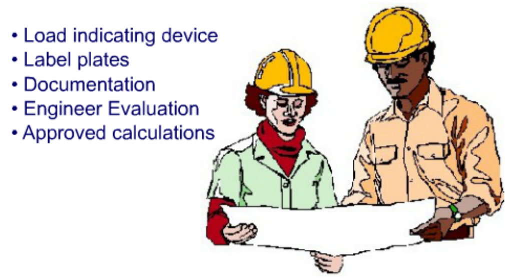
## DETERMINING LOAD WEIGHT

### LOAD WEIGHT

Load weight determines the capacity of the crane and the rigging gear required. Load weight must be verified or calculated whenever it is estimated to exceed 50% of the crane's hook capacity or 80% of the rigging gear capacity.

### ACCEPTABLE METHODS FOR DETERMINING LOAD WEIGHT

Load-indicating devices, label plates, engineering evaluation and calculation are all acceptable methods of determining load weight.




### UNACCEPTABLE METHODS FOR DETERMINING LOAD WEIGHT

Never take word of mouth to establish load weight! Word of mouth may be used as a starting point for sizing the crane and rigging gear so the component can be weighed with a load indicating device, but never shall it be used as the final determination of load weight.

To avoid overloading any equipment used in a crane lift, the rigger-in-charge shall know or have a reasonable estimate of the weight to be lifted. If the weight is estimated to exceed 50% of the capacity of the hoist or 80% of the capacity of the rigging gear, platform/skid, below-the-hook lifting device, etc., the weight shall be verified by performing an engineering evaluation or using a local procedure approved by the certifying official or activity engineering organization. Alternatively, a load indicating device shall be used.

### BASIC RULES FOR DETERMINING LOAD WEIGHT

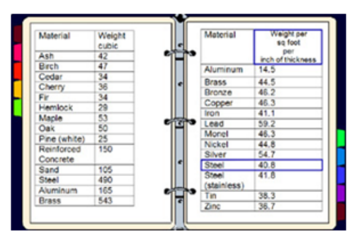
**Guidelines for Determining Weight**

- Round up on the dimensions
- Never mix feet and inches
- Round up on the weight
- Double check your answers

When determining the weight of an object you can always round up the dimensions and the weight, but never round down. Never mix feet and inches and double-check your answers.

### STANDARD MATERIAL WEIGHT

This is a standard chart showing the weights of various materials per square foot, per inch of thickness and weight per cubic foot of volume. This chart is used as an aid when calculating load weights.



| Material | Weight cubic |
|---|---|
| Ash | 42 |
| Birch | 47 |
| Cedar | 34 |
| Cherry | 36 |
| Fir | 34 |
| Hemlock | 29 |
| Maple | 53 |
| Oak | 50 |
| Pine (white) | 25 |
| Reinforced Concrete | 150 |
| Sand | 105 |
| Steel | 490 |
| Aluminum | 165 |
| Brass | 543 |

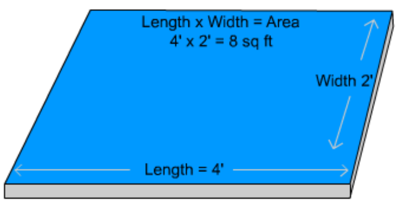
| Material | Weight per sq foot per inch of thickness |
|---|---|
| Aluminum | 14.5 |
| Brass | 44.5 |
| Bronze | 46.2 |
| Copper | 46.3 |
| Iron | 41.1 |
| Lead | 59.2 |
| Monel | 46.3 |
| Nickel | 44.8 |
| Silver | 54.7 |
| Steel | 40.8 |
| Steel (stainless) | 41.8 |
| Tin | 38.3 |
| Zinc | 36.7 |

## FINDING WEIGHT

Weights may be calculated using either area or volume. Find the weight of objects such as plates by multiplying the area in square feet by the material weight per square foot, for a given thickness. To find the weight of three-dimensional objects multiply volume in cubic feet by the material weight per cubic foot. Which calculating method you use, will depend on the item. You may need to use both methods for complex objects.

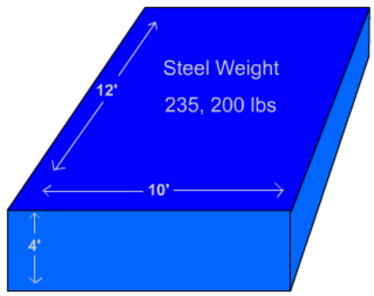
## CALCULATING WEIGHT BY AREA

To calculate the weight of this plate, we must find the area and multiply it by the material weight per square foot. Here, we have a steel plate, 4 feet by 2 feet by 1 inch thick. The area is 8 square feet. To calculate the weight, we need to find the unit weight, or weight per square foot for the material. Using the standard material weight chart, we find steel weighs 40.8 pounds per square foot per inch of thickness. The math can be simplified by rounding to 41 pounds. Multiplying 8 square feet by 41 pounds per square foot gives us 328 pounds.



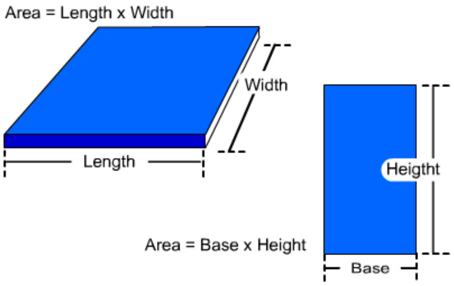

## CALCULATING WEIGHT BY VOLUME

Volume is always expressed in cubic units, such as cubic inches, cubic feet, and cubic yards. Let's calculate the volume of this box. The formula is length, times width, times height. The length is 12 feet. The width is 10 feet. The height is 4 feet. When we multiply 12 times 10, times 4, the volume is 480 cubic feet. Now we can use the standard materials weight chart and multiply the standard weight by the volume.



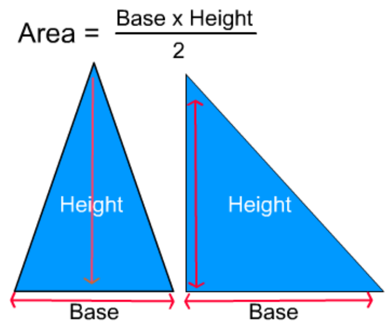

## CALCULATING AREA

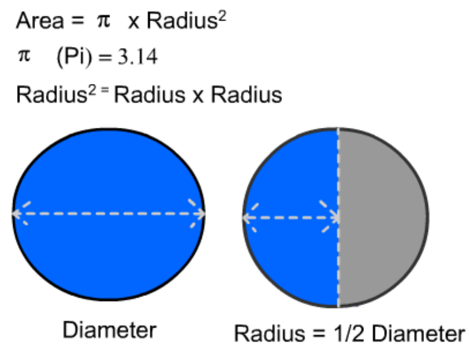
The area of a square or rectangular shaped object is determined by multiplying length times width or base times height. It is always expressed in square units such as square feet or square inches, even when the object is circular.



## Calculating the Area of a Triangle

To calculate the area of a triangle multiply the base of the triangle by the height of the triangle and then divide by 2.



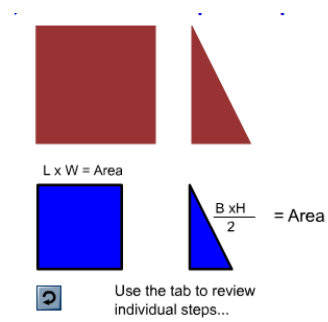




## Calculate the Area of a Circle

To calculate the area of a circle, multiply Pi, which is 3.14, by the radius squared. Find the radius of the circle by dividing its diameter in half. To square the radius, multiply the radius by itself. For example, if a circle has a diameter of 3 feet, the radius will be 1.5 feet. 1.5 feet times 1.5 feet equals 2.25 square feet. Therefore, the radius squared is 2.25 square feet. Pi times the radius squared would be 3.14 times 2.25 square feet, or 7.065 square feet.

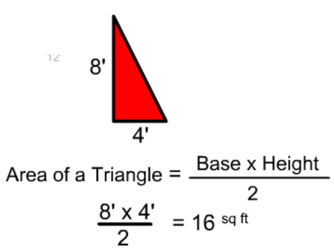
## Calculating the Weight of Complex Shapes 1

Most complex shapes can be broken down into a series of simple shapes. To calculate the area of this complex shape, calculate the area of the square using the formula length times width. Next, calculate the area of the triangle using the formula base times the height divided by 2. Then add the areas together to get the total area of the complex shape.




## Calculating the Weight of Complex Shapes 2

The first step is to calculate the area of the rectangle, or square, as shown in this example. The formula for the area of a rectangle is, length times width. The length is 8 feet and the width is 8 feet. 8 feet, times 8 feet, equals 64 square feet.

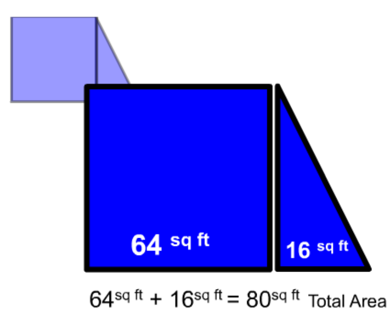


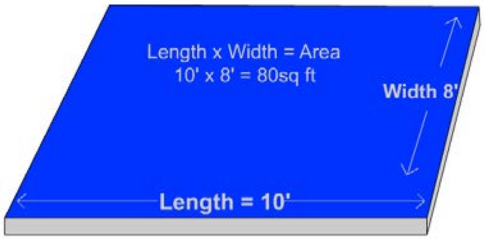

## Calculating the Weight of Complex Shapes 3

Next, find the area of the triangle. The formula for the area of a triangle is, base times height divided by 2. The base is 4 feet and the height is 8 feet. 4 feet times 8 feet equals 32 ft2. 32 ft2 divided by 2 equals 16 ft2.

## Calculating the Weight of Complex Shapes 4

Now that we have found the area of the two sections, all we have to do is add the area of the square to the area of the triangle to find the total area of the object. 64 square feet, plus 16 square feet, equals 80 square feet. If we know what the material is and how thick it is, we can find its weight with one more calculation.



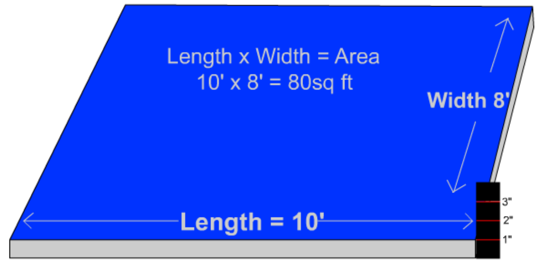



## Calculating Weight Using Area - Rectangle: Step 1

To calculate the weight using area, we must find the material weight per square foot based on its thickness. Then, we simply multiply the base weight by the area of material. The area of this steel plate is 80 square feet.

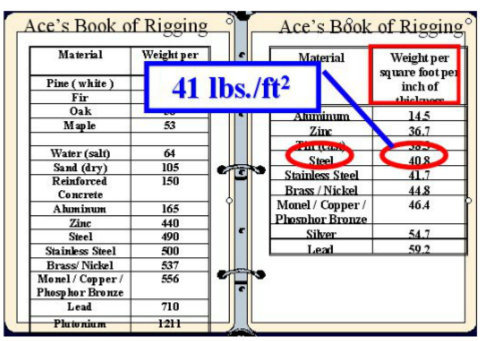
## Calculating Weight Using Area - Rectangle: Step 2

Now we need to know the plate's thickness. According to the ruler, it is 1 inch thick.



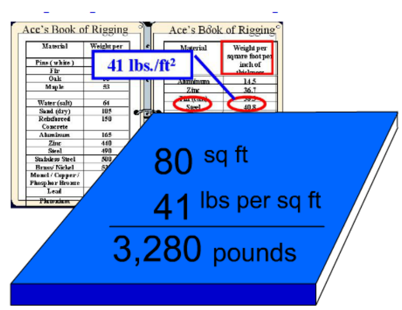

## Calculating Weight Using Area - Rectangle: Step 3

We can find the weight of common materials listed in several reference books available from various industry sources. Here, in "Ace's Book of Rigging", we find these tables. Material weight per cubic foot is in the left table. In the right table, unit weights are listed by weight per square foot, per inch of material thickness. We will use the table on the right since the material weights here are based on the thickness of material. We find steel listed in the "Materials" column. The unit weight is 40.8 pounds per square foot, per inch thickness of steel plate. Now let's apply the rule we learned earlier in the lesson to make the math easier and give us a safety margin in our calculations. What was the rule on rounding that we should apply to this unit of weight? Round up! So, 40.8 pounds per square foot is rounded up to 41 pounds per square foot.



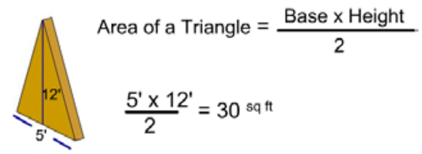

## Calculating Weight Using Area - Rectangle: Step 4

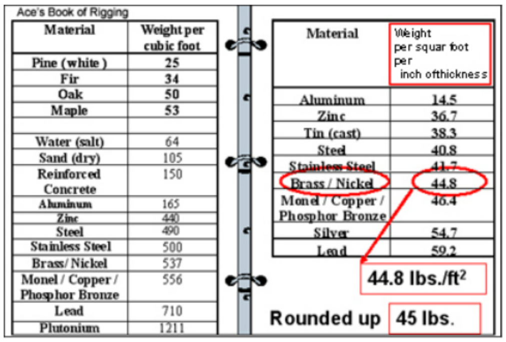
To calculate the weight of the plate: Multiply the area, 80 square feet by the unit weight of 41 pounds per square foot. The weight of the plate is 3,280 pounds. If 1-inch thick steel plate weighs 41 pounds per square foot, a 2-inch thick steel plate would weigh 82 pounds per square foot. What would 1/2 inch thick steel plate weigh per square foot? It would weigh 20.5 pounds.



## CALCULATING WEIGHT USING AREA - TRIANGLE: STEP 1

In this example, we have a triangular shape. How do we find the area of this plate? Multiply the base times the height and divide by 2. 12 times 5, divided by 2. The area of this plate is 30 square feet.



Ace's Book of Rigging

| Material | Weight per cubic foot |
|---|---|
| Pine (white) | 25 |
| Fir | 34 |
| Oak | 50 |
| Maple | 53 |
| | |
| Water (salt) | 64 |
| Sand (dry) | 105 |
| Reinforced Concrete | 150 |
| Aluminum | 165 |
| Zinc | 440 |
| Steel | 490 |
| Stainless Steel | 500 |
| Brass/ Nickel | 537 |
| Monel / Copper / Phosphor Bronze | 556 |
| Lead | 710 |
| Plutonium | 1211 |

| Material | Weight per squar foot per inch ofthickness |
|---|---|
| Aluminum | 14.5 |
| Zinc | 36.7 |
| Tin (cast) | 38.3 |
| Steel | 40.8 |
| Stainless Steel | 41.7 |
| Brass / Nickel | 44.8 |
| Monel / Copper / Phosphor Bronze | 46.4 |
| Silver | 54.7 |
| Lead | 59.2 |

44.8 lbs./ft²

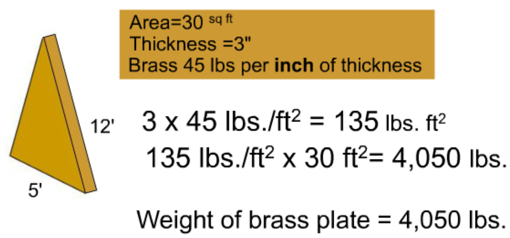
Rounded up 45 lbs.

## CALCULATING WEIGHT USING AREA - TRIANGLE: STEP 2

To find the weight of this plate, we have to multiply the area (30 square feet) by the unit weight of the material per inch of thickness. The material is brass, and the thickness is 3 inches. To find the total weight of the material we need to reference a table or chart to obtain the unit weight.

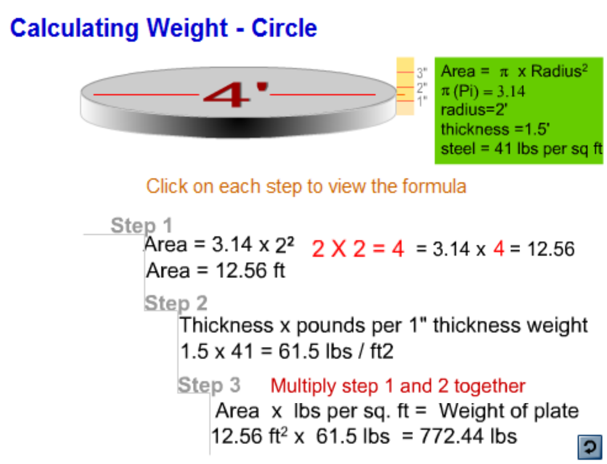
## CALCULATING WEIGHT USING AREA - TRIANGLE: STEP 3

We now know that brass weighs 45 pounds per square foot, per inch of thickness. We multiply the thickness, 3 inches, by the unit weight of 45 pounds. The material weighs 135 pounds per square foot. Next, we multiply the area, 30 square feet, times the weight per square foot, 135 pounds. We find that this item weighs 4,050 pounds.



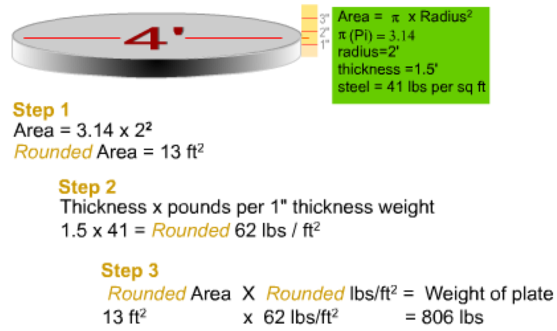

## CALCULATING WEIGHT USING AREA - CIRCLE

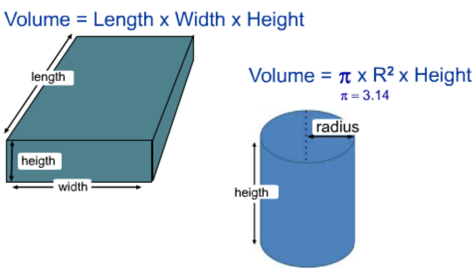
To calculate the area of a circle, multiply Pi, 3.14, by the radius squared. This steel plate is 4 feet in diameter. Therefore, the radius is 2 feet. The plate is 1 ½ inches thick. To find the area: multiply Pi, or 3.14 times the radius squared. 3.14 times 2, times 2 equals 12.56 square feet. To find the weight per square foot: multiply the plate thickness, 1 ½ inches, times the weight of 1 square foot of 1-inch thick steel. 1.5 times 41 equals 61.5 pounds. To find the weight: multiply the area, 12.56 times the unit weight of 1 ½ inch thick steel plate which is 61.5 pounds. The weight of this circular steel plate is 772.44 pounds.



## ROUNDING OFF

Rounding numbers make calculations easier. Always round up. Rounding up give a larger area and heavier weight, therefore an added safety margin. Round up the plate area and the weight. The area, 12.56 square feet, rounded is 13 square feet. The weight, 61.5 pounds, rounded is 62 pounds. 13 times 62 equals 806 pounds.



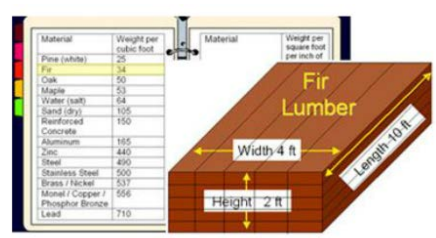




## CALCULATING VOLUME

The volume of a square or rectangular object is figured as length times width multiplied by the height. The volume of a cylinder is Pi times the radius squared, times the height.

## CALCULATING WEIGHT USING VOLUME

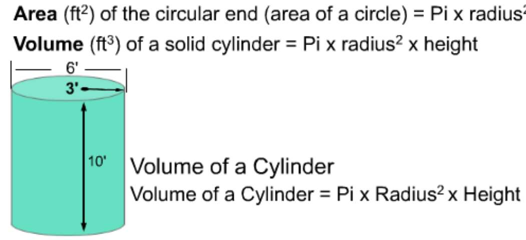
To calculate weight by volume, we need to find the unit weight, or weight per cubic foot for the material. We go back to the tables to find the weight for a cubic foot of fir wood. This time we will use the table on the left since the material weights listed here are based on the weight per cubic foot of material. Using the standard material weight chart, we find that fir weighs 34 pounds per cubic foot. If the weight were listed in fractions or decimals, such as 33.8 pounds per cubic foot, we would simplify the math by rounding 33.8 up to 34 pounds. Multiplying 80 cubic feet by 34 pounds equals 2,720 pounds. This stack of lumber weighs 2,720 pounds.

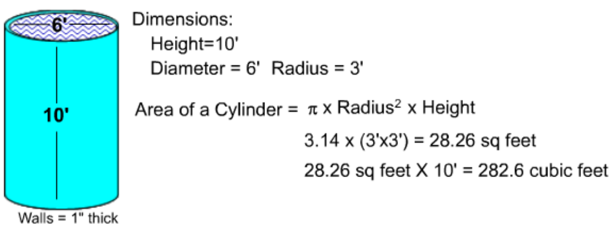



80 cubic feet of fir lumber
X 34 pounds per cubic foot
2,720 pounds load weight

## Calculating Weight Using Area & Volume: Cylinder 1

What is the formula for finding the volume of a cylinder? To calculate the volume we must first find the area of the circular end. The formula for area is Pi times radius squared. Once we know the area, we simply multiply it times the height or length. So the formula we use to find the volume of a solid cylinder is, Pi times radius squared times the height. If the cylinder were lying down you would use its length in place of the height.



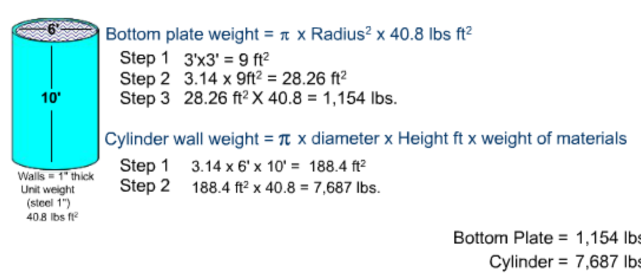




## Calculating Weight Using Area & Volume: Cylinder 2

Let's calculate the volume of this cylinder. If the diameter of this object is 6 feet, what would the radius be? The radius would be 3 feet. The height is 10 feet. We multiply Pi, which is 3.14 times 3 feet times 3 feet. The result is 28.26 square feet. Now, multiply 28.26 square feet, times the height, 10 feet. The result is the volume of this cylinder, 282.6 cubic feet. If the cylinder is hollow, we will need to calculate the volume of the cylinder and the volume of the contents separately. Calculate the volume as if the cylinder is solid. Then calculate the volume of the hollow. Subtract the volume of the hollow section from the volume of the solid cylinder.

## Calculating Weight Using Area & Volume: Cylinder 3

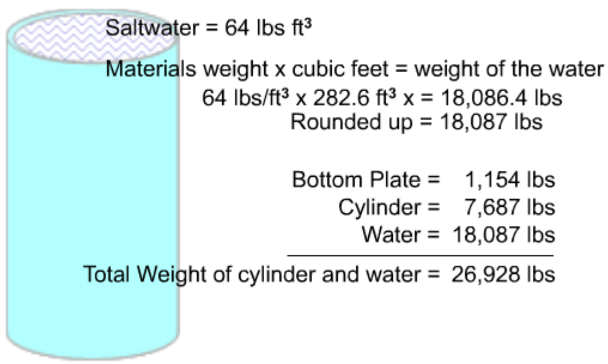
One inch steel plate weighs 40.8 pounds per square foot. The bottom plate is 6 feet in diameter, so the radius is 3 feet. 3 feet squared equals 9 square feet. We multiply 9 square feet by 3.14. This gives us the area, 28.26 square feet. We multiply this by the unit weight for steel plate (40.8 pounds per square foot). The bottom plate weighs 1,154 pounds. Calculate the cylinder wall weight as a flat plate. Multiply Pi, (3.14) by the diameter, 6 feet, and then by the height, 10 feet. Multiply the area, 188.4 square feet, by the weight of the steel plate, 40.8 pounds per square foot. The resulting weight is 7,687 pounds.



## Calculating Weight Using Area & Volume: Cylinder 4

Using the volume calculation, let's find the weight of the water contained in this thin-walled cylindrical tank. Let's calculate the weight of this cylinder full of salt-water. We need to know the weight per cubic foot of salt water. Looking at our material weight chart we see saltwater weighs 64 pounds per cubic foot. We multiply the material weight times the cubic feet to find the weight of the water in the cylinder. 282.6 cubic feet times 64 pounds per cubic foot equals 18,086.4 pounds.

Now we will add up the weights: 1,154 pounds for the bottom plate, 7,687 pounds for the cylinder wall; and 18,087 pounds of water, for a total load of 26,928 pounds.

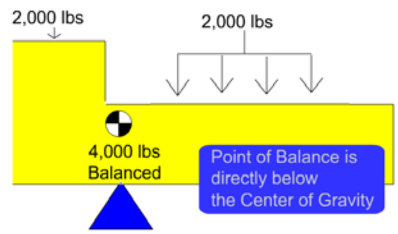


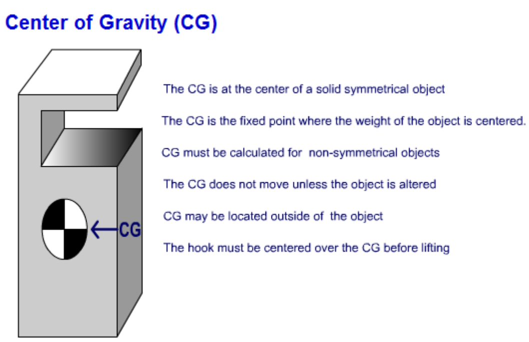
# NOTES

## Load Weight Distribution

### Balancing Point/Center of Balance

An object will rest in a state of balance when supported at its balance point. The balance point may not be located at the center of an object, but it is always directly below the center of gravity.



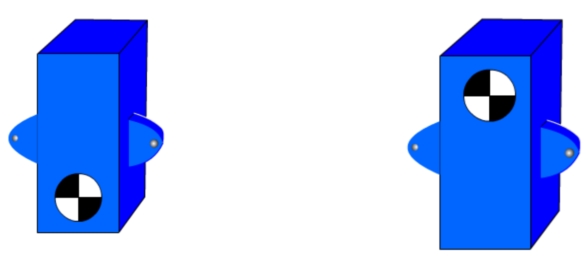




### Center of Gravity

The center of gravity is the point where the entire weight of the object would balance in any direction, as if all the weight were concentrated in that one point. It is a fixed point and does not change unless the shape of the object is altered. Center of gravity is generally located in the center of symmetrical objects made of like material. For non-symmetrical objects, it must be calculated and could be located outside the object.

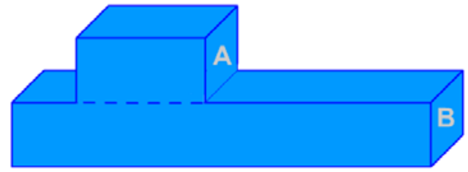
### Importance of Center of Gravity

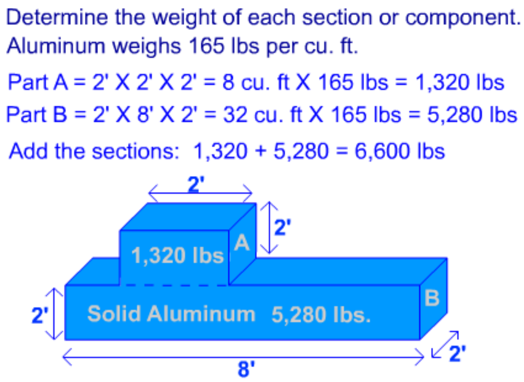
The location of the center of gravity will affect an object's reaction to movement. If the attachment points are below the center of gravity, the object will tip over more easily when moved. If the attachment points are above the center of gravity, the object is not likely to tip.



## Finding the Balance Point: Step 1

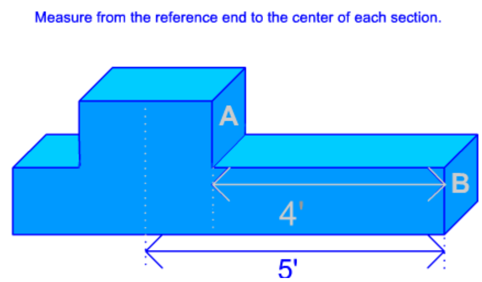
The balance point of a symmetrical object will be directly under its center. To find the balance point of a complex shape, we must first break the object into symmetrical sections or components.



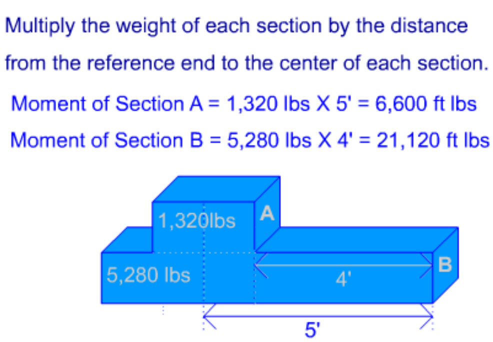

## Finding the Balance Point: Step 2

The second step is to determine the weight of each section.



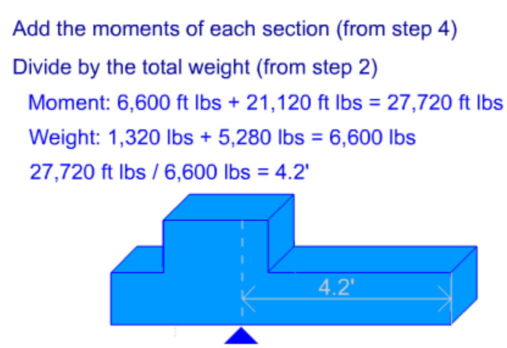

## Finding the Balance Point: Step 3

The next step is to measure from the reference end to the center of each section of the object.




## Finding the Balance Point: Step 4

Then, multiply the weight of each section, by the distance from the reference end to the center of that section. The result is called moment. Moment is an effect produced by a force at some distance from a fixed point, such as the center of gravity. Moment, like torque, is often described in foot-pounds or pound-feet.




## Finding the Balance Point: Step 5

Add the moments together and divide this number by the total weight of the object. The balance point is where the moments, measured from each end, are equal.

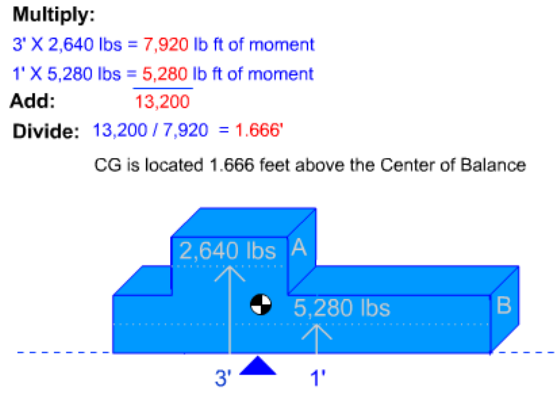
## PINPOINTING THE CENTER OF GRAVITY

In this example the weight of section A is 2,640 pounds.

The weight of section B is 5,280 pounds.

Measure the distance from the reference end to the center of each section. Multiply the weight of each section by the distance from the reference end to the center of the section to obtain the moment.

The distance from the reference line to the center of section A is 3 feet and the distance from the reference line to the center of section B is one foot. The moment for section A is 7,920 feet. The moment for section B is 5,280 pound feet.

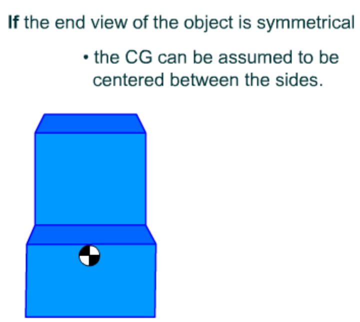



Add the moments together and divide by the total weight to find the height of the center of gravity.

7,920 plus 5,280 equals 13,200 pound-feet. The weight is 2,640 plus 5,280 or 7,920 pounds.

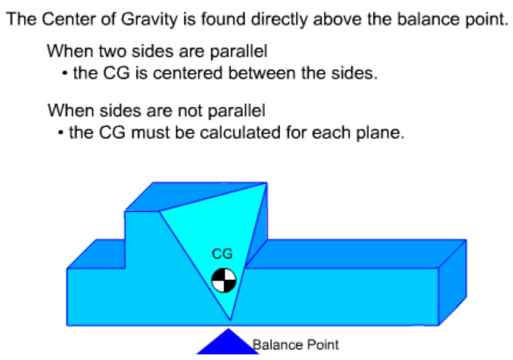
Now divide 13,200 by 7,920. The center of gravity is 1.666 feet up from the reference end.

If we convert decimal feet to inches, this equals 1 foot, 8 inches.




## FINDING CG DEPTH

To find the depth of the center of gravity, follow the five-step process using the front of the object as the reference end for step 3. In this example, the end view shows the object is symmetrical. Therefore, we can assume the center of gravity is in the center of the object –one foot from the front.

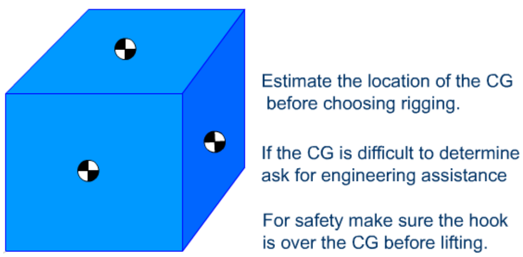


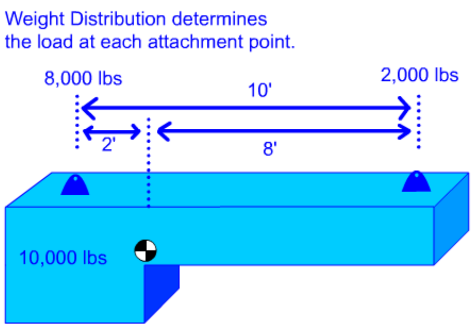

## Center of Gravity Pinpointed

The object's center of gravity is always directly above the balance point. It may be helpful to measure and temporarily mark the object's center of balance before rigging.

## Center of Gravity Review

Remember to estimate the location of the Center of Gravity in relation to the attachment points before rigging or lifting loads. If the center of gravity is difficult to estimate, you may need engineering assistance. Loads hoisted from the bottom without restraint are susceptible to tipping. Loads should be lifted from their top, or restrained within the slings. If a load is hoisted without keeping the hook over the center of gravity, the load will shift as it clears the ground. Sometimes the rigging must be re-adjusted before making the lift.



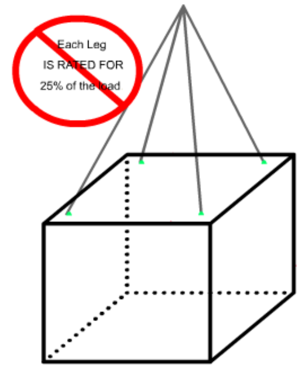



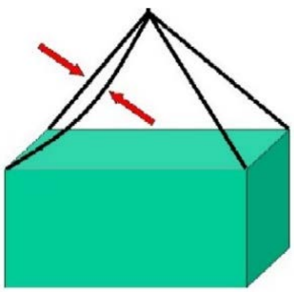

## Weight Distribution

The center of gravity provides a quick reference for how the weight is distributed throughout a load. However, before planning the lift it is necessary to refine how the load weight is distributed. Weight distribution determines what each attachment point will have to carry. This information insures the selection of correctly rated rigging gear

## A Wrong Assumption

A common assumption is that 4 legs divide the load weight into 4 equal parts. Each leg then carries 25% of the load. Most often, this is not true.



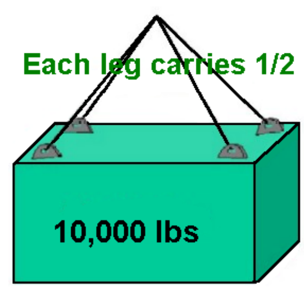
## How Many Legs Really Carry the Load?

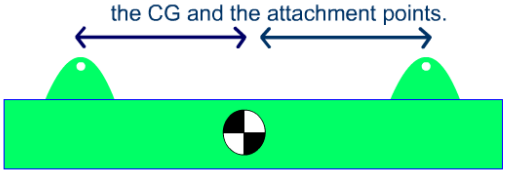
We now understand that each leg will not always carry its share of the load. In this example, one sling is longer than the others. Therefore that attachment point will not carry its share of the load. No two slings are fabricated exactly the same length. When one sling is longer than the others, when shackles or other hardware are different brands or sizes, or when one attachment point is higher than the others, one or more attachments may not carry any load at all. Don't assume that all legs will carry their share of the load.

## A Safe Assumption

Here is a safe assumption:

At any given time, any two legs may carry the load, even if three or more legs are used. The “two-legs-carry-the-load” rule helps us to compensate for different sling lengths, attachment points at different elevations, and load flex. Gear selections should be based on two legs being able to carry the load. For example, if an object weighs 10,000 pounds then each leg would require a rated load of at least 5,000 pounds.



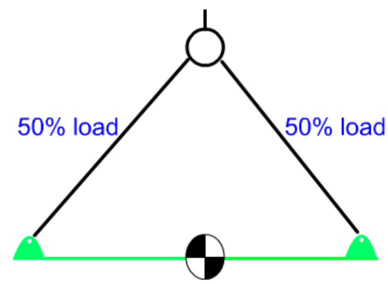



## How Do We Know How Much Weight in in Each Leg?

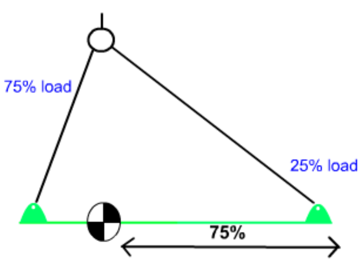
Gear selection is dependent upon how much weight is carried by each leg - the load's weight distribution. Weight distribution is proportional to the distance between the object's Center of Gravity and its attachment points The distances between the Center of Gravity and the attachment points will determine how much of the weight each attachment point will carry

## Equal Weight Distribution

This drawing represents a load. Notice the difference in weight distribution as the center of gravity changes distance from each attachment point. In this first example, each attachment carries equal weight because the center of gravity is equal distance between the attachment points. Watch the left attachment point as we move the center of gravity.



When distances between the CG and attachment points are equal, weight distribution is also equal.



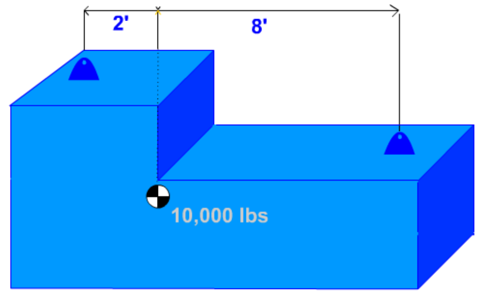
When distances between the CG and attachment points are unequal, weight distribution is inversely proportionate.

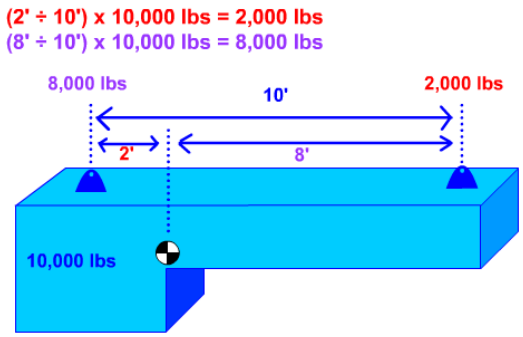
## Unequal Weight Distribution

In the second example, the weight is greatest in the left attachment point because it's closest to the center of gravity. When one attachment point is closer to the center of gravity than the other attachment point, it carries more weight. It carries 75% of the weight and the opposite end carries 25%.

## Information Needed to Calculate Weight Distribution

Now, let's move beyond estimating and show how to calculate the weight distribution. In order to calculate weight distribution, you must know the object weight, the location of the center of gravity and the distance of each attachment point from the center of gravity.




## Weight Distribution Example

If we want to find out how much weight is distributed to the attachment closest to the center of gravity, we divide the 8-foot distance by the overall distance between attachment points, which is 10 feet. Then we multiply this answer by the total weight of the object.

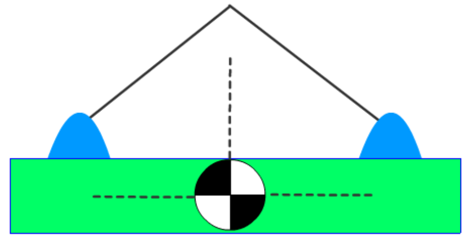
Eight divided by 10, times 10,000 equals 8,000 pounds.

# NOTES

## Sling Angle Stress

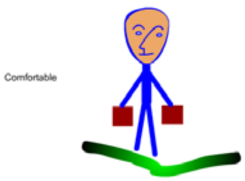
### What is Sling Angle Stress?

What is sling angle stress? It is the added force created in the rigging when the slings are not perfectly plumb, vertical, and parallel.

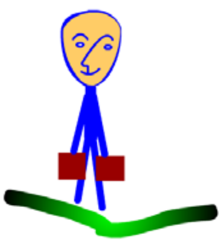


### Sling Angle Stress Illustration

It may be beneficial to use an illustration that we can relate to. Though this is not exactly sling angle stress, it illustrates the concept very well.





### Sling Angle Stress – 90°

Here's Ace. He is holding a fifty-pound weight in each hand. His arms are vertical, similar to a 90° horizontal sling angle. The amount of stress in Ace's arms is equal to the amount of weight he's holding, fifty pounds. See what happened as Ace moved his arms increasingly further away from his body.

### Sling Angle Stress – 45°

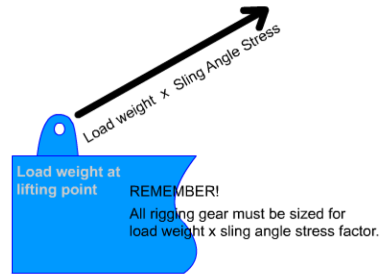
When Ace has his arms at a 45° angle the stress in his arms increases even more. The stress increase is 42% of the weight he's holding. It feels like he's holding 71 pounds in each arm.

### Sling Angle Stress – 30°

At a 30° angle, the amount of stress in Ace's arms increases further. The stress increase at 30° is 100% of the weight he's holding. Now Ace feels like he's holding 100 pounds in each arm even though the weight is still actually 50 pounds. This same effect, called sling angle stress, occurs in rigging gear because the legs of a lift are almost always at angles. This additional stress must be considered when selecting rigging gear.

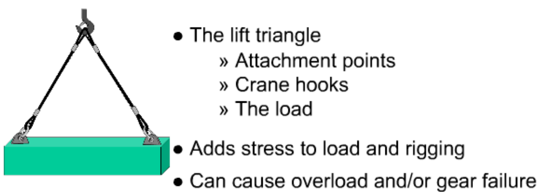
## CHOOSING YOUR GEAR

The two-leg rule is followed when choosing gear capacities for a lift. Rigging gear must have a capacity greater than the applied load. The load applied to the rigging gear includes the weight carried by the attachment points multiplied by the sling angle stress factor.



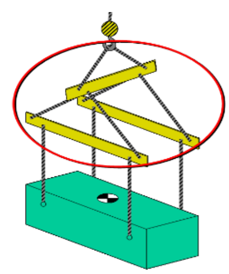

## WHAT DOES IT AFFECT?

Nearly every lift creates a triangle. All of the components that make up the sides of a lift triangle are affected by sling angle stress including the attachment points on the load, the crane hook, the rigging gear and the load itself. Sling angle stress can cause the load to flex and sag. Excessive sling angle stress can cause a choker hitch or basket hitch to crush a fragile item. Remember, sling angle stress does not change the weight of the load being lifted; only the load on the rigging.




## MINIMIZING SLING ANGLE STRESS

Sling angle stress can be minimized by using spreaders or other below the hook lifting devices. Lifting beams or strong-backs can help ensure each sling is carrying its share of the load and that the load remains level. Sling angles may still affect the rigging gear between the hook and spreaders, even if the slings between the spreader and the load are vertical!

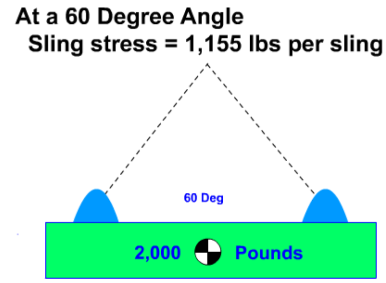


## SLING ANGLE STRESS SUMMARIZED

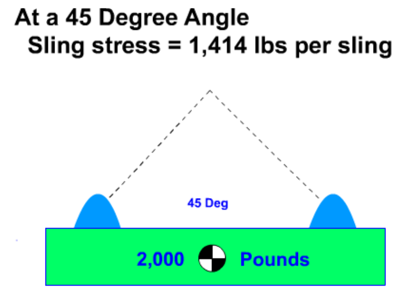
When referring to the effects of sling angle, we refer to horizontal sling angle. In other words, we are measuring the angle created between the sling and a horizontal line through the attachment points. Sling angle stress is proportional to the degree of the angle from horizontal. The more vertical the angle - the less added force. The more horizontal the angle - the greater the added force. Let's look at this principle on a load.

## EFFECTS OF SLING ANGLE STRESS

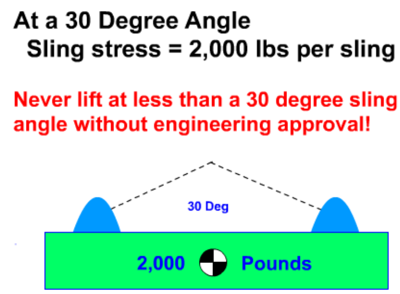
At a 60° angle the load on the rigging has increased to 1,155 pounds. Keep in mind each leg has 1,155 pounds of stress even though only one leg is shown.60° is the preferred angle.




At a 45° angle the load has increased to 1,414 pounds in each sling. That's nearly a 42% increase.

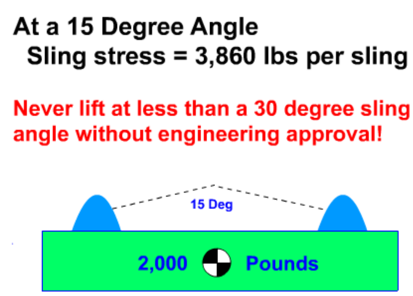



At a 30° angle the stress has increased to 2,000 pounds. Each sling now has a load equal to the weight of the object. That is a 100% increase.




Never lift with less than a 30° angle without engineering approval.

At a 15° angle the load has increased to 3,860 pounds. That's a 286% increase in each sling.



## WHY WE ACCOUNT FOR SLING ANGLE STRESS

Not accounting for sling angle stress can lead to overloaded rigging gear and even catastrophic failure.

## SELECTING MINIMUM RATED CAPACITY

Remember, two legs must have the capacity to lift the weight of the object, plus the added force from sling angle stress. After we calculate the sling angle stress, we can determine the minimum requirements for our rigging gear.

## DETERMINE MINIMUM RATED CAPACITY

There are several ways to determine sling angle stress. We will use the angle factor chart, as it is readily available and easy to use.

| Horizontal Angle | Angle Factor |
|---|---|
| 90 | 1.000 |
| 85 | 1.004 |
| 80 | 1.015 |
| 75 | 1.035 |
| 70 | 1.064 |
| 65 | 1.104 |
| 60 | 1.155 |
| 55 | 1.221 |
| 50 | 1.305 |
| 45 | 1.414 |
| 40 | 1.555 |
| 35 | 1.742 |
| 30 | 2.000 |
| 25 | 2.364 |
| 20 | 2.924 |
| 15 | 3.861 |
| 10 | 5.747 |
| 5 | 11.490 |

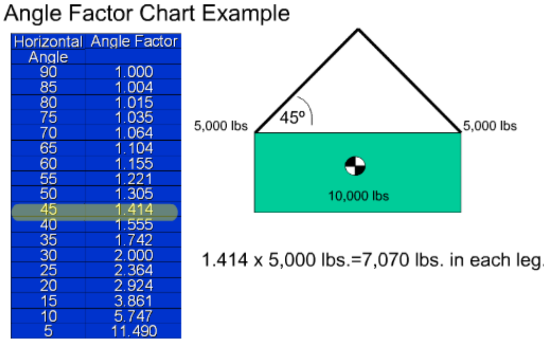
## USING THE ANGLE FACTOR CHART

To use an angle factor chart, you first need to determine the sling angle. Sling angle can be determined mathematically or measured. Once you have determined the sling angle, find the corresponding angle factor, and multiply that number by the weight carried in each leg. When you look at the angle factor column, you will notice a dramatic increase for angles less than 30°. That's why we do not use sling angles less than 30° unless authorized by an engineering document.

## ANGLE FACTOR CHART EXAMPLE

This shape represents the lift we are about to make. Let's say that the angle created by the slings we use is 45°. The angle factor for a 45° angle is 1.414. We must multiply the angle factor, 1.414 by the weight carried in the leg.

Angle Factor Chart Example

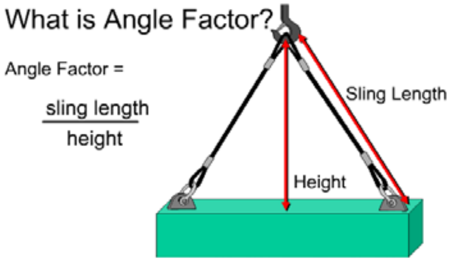



How much weight will the leg carry?

That's right, 5,000 pounds.

1.414 times 5,000 equals 7,070 pounds. This is the total stress in each leg!

This number represents the minimum gear capacity that can be used for the lift.

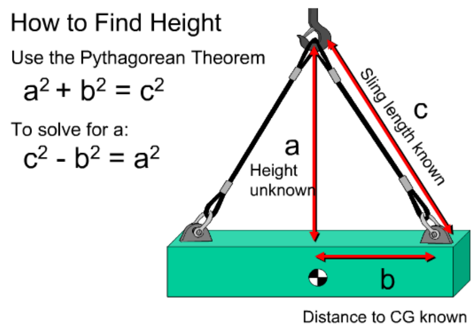



## WHAT IS ANGLE FACTOR?

Remember the lift triangle? Now the whole triangle idea really comes into play. The sling angle factor is a ratio of the side of the lift triangle, which in this case is the sling, and the height of the triangle. To find it, divide the sling length by the height of the lift triangle. The height is the distance between the bearing area of the hook and an imaginary line running horizontally from the bearing area of the attachment point. If you cannot measure the height, it can be found mathematically.

## HOW TO FIND HEIGHT

The Pythagorean theorem states that the length of a side of a right triangle squared, equals the length of the base squared plus the height squared.




A squared, plus B squared, equals C squared.

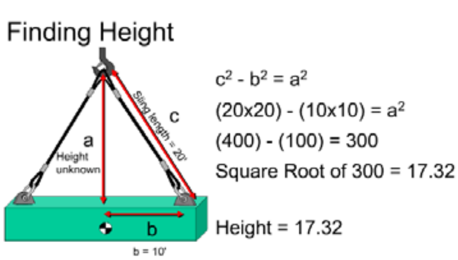
Here the height of the lift triangle is A, the horizontal base is B and length of the sling is C.
Only A, the height, is unknown. To find the unknown height, A, use this variation: C squared minus B squared equals A squared.

## FINDING HEIGHT: EXAMPLE

Use C squared minus B squared equals A squared to solve for height.

The sling, C, is twenty-feet long. Multiplying the sling length times itself gives us C squared. In this case, that is twenty times twenty or four hundred.

We measure the horizontal distance from the bearing area of the attachment to the top of the load directly above center of gravity. This dimension, B, is ten feet. We multiply this number by itself.




10 times 10 = 100.

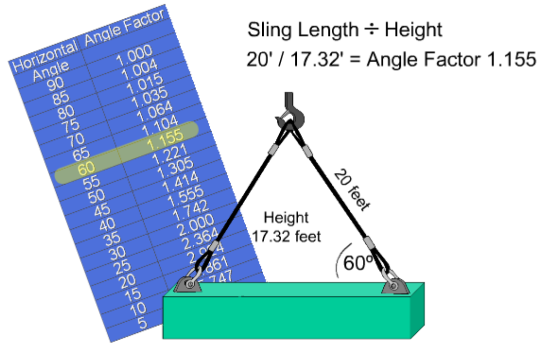
Subtract 100, which is B squared, from 400, which is C squared. Therefore A squared equals 300.

Now we use the square root function on our calculator to calculate the square root of 300.

The height equals the square root of 300, which is 17.32 feet.

## Finding Angle Factor 1

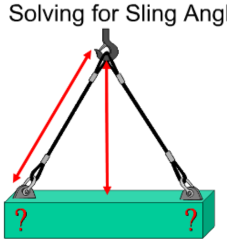
Remember the angle factor equals sling length divided by height. We just found the height of the lift triangle. Now, here's how to find the angle factor: The sling is 20 feet long and we found the height to be 17.32 feet.




20 divided by 17.32 equals 1.155. This is our angle factor.

Finally, we will multiply the angle factor by the amount of weight at the attachment point.

Solving for Sling Angle Stress Mathematically



(Sling Length ÷ Height) **x** Weight Distribution = Sling Angle Stress

## Finding Angle Factor 2

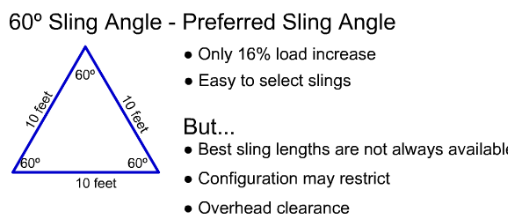
Now we can use everything we've covered thus far to solve for sling angle stress. Here's the formula:

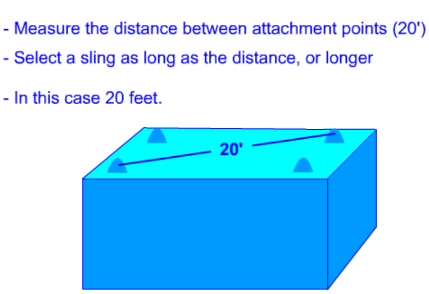
sling length **/** height **x** weight distributed to each leg

Remember, weight distribution is determined by the distance from the center of gravity to the attachment points. This works for all lifts with level attachment points.

## 60° Sling Angle

60° is the preferred sling angle. At 60°, the load in the slings increases by 16%.



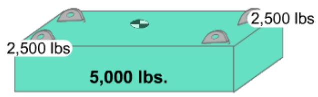




## Determining Sling Length for a 60° Angle

To ensure your slings will have at least a 60° sling angle simply measure the distance between attachment points. Measure diagonally when there are more than two attachment points because it's the longest distance. Then select a sling that is as long or longer than the distance measured. If you use this method to select your slings, you will never have a sling angle less than 60°.

## Determining Minimum Rated Capacity for 60° Sling Angles

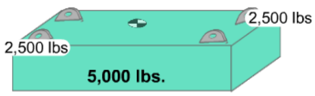
Now we can easily determine the stress in the rigging before we and attach the gear. Let's say the weight of the object is 5,000 pounds. How much weight would each attachment point carry? Each would carry 2,500 pounds. What is the angle factor for a 60° sling angle? The angle factor is 1.155. Multiply the angle factor, 1.155, times the weight distributed to the attachment point, 2,500 pounds. 2,888 pounds is the stress in the rigging gear and attachment points. It is also the minimum capacity for all rigging for this lift.




60° angle Factor of **1.155**

**1.155** x 2,500 lbs. = 2,888 lbs. Stress

Minimum capacity sling and rigging gear require 2,888 lbs.



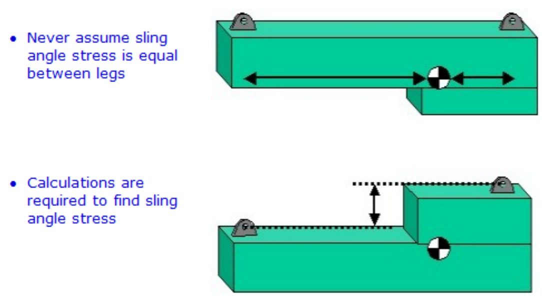

30° Angle Factor = **2.00**

**2.00** x 2,500 lbs. = 5,000 lbs. stress

Minimum capacity sling and rigging gear require 5,000 lbs.

## Determining Minimum Rated Capacity for 30° Sling Angles

Using the same weight, let's look at the minimum rated capacities for a 30° sling angle. The angle factor for 30° is 2. At a 30° sling angle, the rigging and attachment point stress will double. Two times 2,500 pounds equals 5,000 pounds of stress. The minimum capacity sling and rigging gear required is five thousand pounds.




## Unlevel / Unequal distances from CG

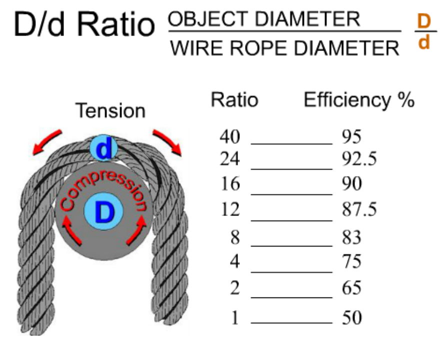
Where the center of balance is not equally distant between attachment points or when attachment points are on different levels, sling angle stress will not be equal between legs and extra calculations will be required. Contact your supervisor and consult the activity engineers for guidance when there is a question about sling angle stress for these types of lifts.

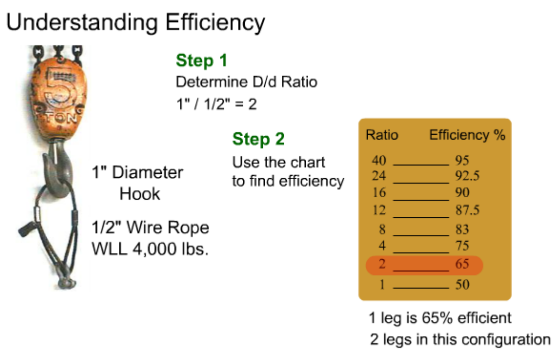
# NOTES

## D/d Ratio

### D/d Ratio

D/d ratio is the relationship between diameter of an object that a sling is bent around to the diameter of the sling. D/d ratio is generally applied to wire rope slings. The tighter the bend, the greater the loss of strength. The sling can be weakened and severely damaged if it's bent around a diameter smaller than its own diameter. To determine how the bending will affect the sling: divide "D", the object diameter by "d", the sling diameter. The result is the D/d ratio. Use table fourteen-three in the P-307 to determine sling efficiencies at various D/d ratios.

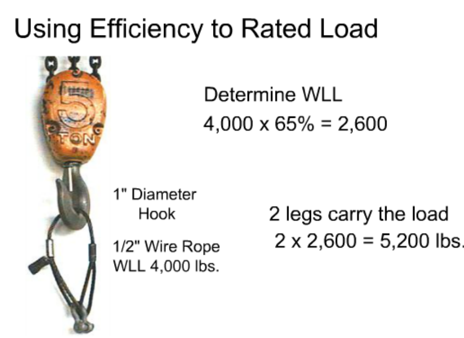



### Understanding Efficiency

Here we have a 1/2-inch wire rope sling with a rated load of 4,000 pounds, bent around a 1-inch hook. The first thing we must do is determine the D/d ratio. The hook diameter is 1 inch and the sling diameter is 1/2 inch. 1 divided by 1/2 equals 2. The D/d ratio is 2. Looking at the chart, we see that a D/d ratio of 2, provides 65% efficiency. One leg is 65% efficient. There are two legs in this configuration.

### Using Efficiency to Find Rated Load



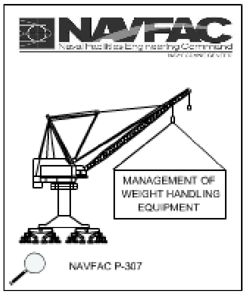

Now that we know the efficiency, let's figure out the maximum weight that could be lifted in this configuration. First, we must determine the rated load of each leg. We multiply the rated load by the efficiency; 4,000 times .65 or 65%, equals 2,600.2,600 pounds is the rated load for one leg. When we double a sling over an object, we effectively create two legs. Since two legs are carrying the load, we multiply the rated load by 2. 2,600 times 2 equals 5,200. This is the rated load of the doubled sling. Whenever we bend a wire rope around an object, or double our wire rope slings, this D/d ratio must be calculated. For D/d ratios that fall between the values shown, use the lower efficiency.

### D/d Calculations

The D/d principle also applies to slings bent around corners. In this case, the diameter of the curvature of the sling as it bends around the corner of the object to be lifted must be determined. For many applications, special fittings such as pipe sections are placed on the corners of the object to ensure a large enough diameter of curvature for the sling so as not to reduce the sling efficiency too greatly.

# NOTES

## RIGGING GEAR MARKING AND RECORD REQUIREMENTS




### NAVFAC P-307 SECTION 14

Let’s look at the section of NAVFAC P-307 that deals with rigging, Section 14. Section 14 provides administrative and technical requirements for inspection, testing, certification, alteration, repair, operation, and use of rigging gear. These requirements help ensure the rigging gear you use is safe. When followed, these requirements help ensure optimum service life of the gear. These requirements apply to Navy owned gear and to contractor owned gear used with Navy owned cranes.

### TEST AND INSPECTION PROGRAM

P-307 requires each activity to establish a program that includes initial visual inspection and load test of all equipment and markings, pre-use inspections before equipment is used, documented periodic inspections of all equipment, and documented periodic load tests of certain equipment.

### WHY TEST AND INSPECTION?

Why do we need a test and inspection program? The primary goal is to prevent personnel injury. The test and inspection program is designed to identify sub-standard, defective, damaged, or worn equipment, and remove unsafe equipment from service.

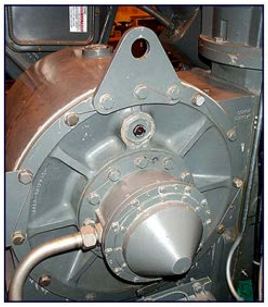
### COVERED EQUIPMENT 1

Test and inspection requirements apply to the following equipment used in weight handling operations: rigging hardware such as shackles, links and rings, swivels, eye bolts, swivel hoist rings, turnbuckles, and hooks. These requirements also apply to slings including chain slings, wire rope slings, metal mesh slings, synthetic web slings, synthetic rope slings and synthetic round slings. These requirements also apply to crane structures without permanently mounted hoists.

### COVERED EQUIPMENT 2

Equipment covered includes manually operated hoists as identified in ASME B30.16 and B30.21 which include chain hoists and lever operated hoists. Equipment covered also includes miscellaneous equipment, including below the hook lifting devices as identified in ASME B30.20, such as spreader beams, plate clamps, magnet lifters, pallet lifters, and tongs.

### EQUIPMENT NOT COVERED



Equipment not covered includes ordnance equipment, which falls under NAVSEA OP-5, original equipment manufacturer or OEM installed welded lift lugs, threaded holes and bolt-on pads, and OEM provided rigging gear used for limited lifts such as off-loading, re-loading, initial storage, and shipment.

### EQUIPMENT MARKINGS

Markings on each piece of equipment are the most apparent way for you, the user, to know the requirements of NAVFAC P-307 have been met. Each piece of equipment must be clearly marked, tagged or engraved with the rated load of the equipment, an indication of the re-inspection due date, and a unique serial number. Below the hook lifting devices weighing more than 100 pounds shall be marked with the weight of the device. Markings must be done in a manner that will not affect the strength of the component. Vibra-etch methods and low stress dot faced stamps are acceptable methods for marking equipment. Contact the OEM for guidance on where and how to mark equipment.

### SPECIAL ROUNDSLING MARKINGS

NAVFAC P-307 has additional requirements for alternate yarn roundslings. Alternate yarn roundslings are roundslings made from yarns other than nylon or polyester. The certificate of proof test must include the diameter of the pin used for the proof test. This will be the minimum diameter over which the sling may be used. The sling must be marked with the minimum allowable pin diameter.

### WIRE ROPE ENDLESS SLING MARKINGS

In non-specific use applications endless slings shall have a marked rated load based on a D/d efficiency of 50 percent and may be used over various size pins at loads not exceeding the marked rated load. In specific applications where endless wire rope slings are designed for a particular use, they shall be marked to indicate the pin diameter used to determine the rated load.

## CHAIN SLING MARKINGS

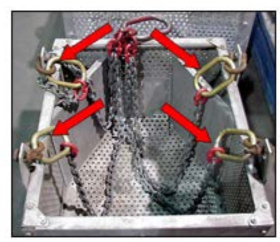
In accordance with 29 CFR 1915.112 and 29 CFR 1917.42, chain slings used in ship repair or cargo transfer require quarterly periodic inspections and must be marked to show the month and year they were inspected.

## LASHING MARKINGS

Lashing must be marked to identify it to the spool or reel from which it came. The rated load must be marked on each piece as well as the re-inspection due date.

## MULTI-PART EQUIPMENT MARKINGS

Some rigging gear has multiple parts that can disassembled. To help avoid miss matching parts, all individual components of equipment such as shackles and pins must be identified to each other. Matching ID marks are needed on the primary and subordinate parts.



## MULTI-LEG SLING ASSEMBLY MARKINGS

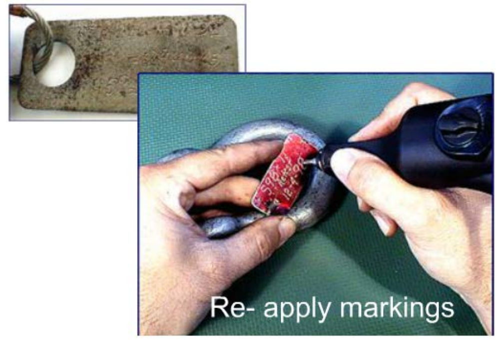
Multi-leg slings assemblies shall be marked with the rated load of each leg, the rated load of the entire assembly, and the sling angle upon which the rated load is based.

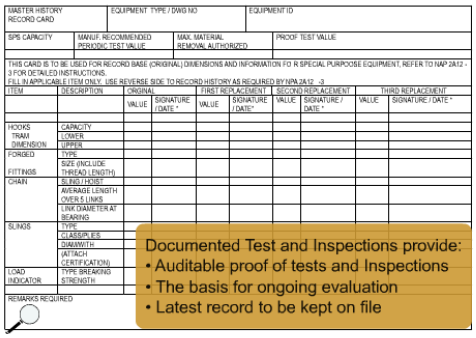
## MULTI-PART WIRE ROPE SLING MARKINGS

NAVFAC P-307 requires that multi-part braided slings must have the OEM's marking re-marked at 70% of the OEM's rated load unless destructive tests are conducted on sample slings. The documentation is reviewed by the Navy Crane Center. So, there are many additional markings that may be required for different equipment. Not only do these markings have to be present, they must be legible.

## Illegible or Missing Markings

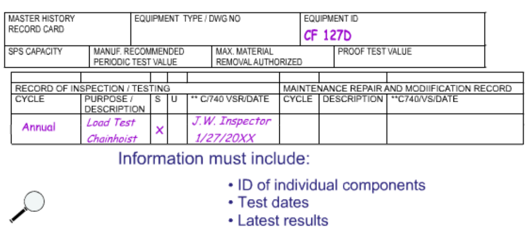
Sometimes markings become hard to read due to wear or they may even be removed during a repair process. Replace markings that are hard to read or have been removed. Remember, all rigging equipment must be marked.




## Required Records

Equipment markings should link the piece of equipment to its test and inspection records. NAVFAC P-307 requires documentation of tests and inspections. Records are the auditable proof that equipment has been tested and inspected and provide a basis for ongoing evaluation of the equipment. The latest test and inspection record will be retained on file at the activity. Computer generated files are acceptable if they identify the individual components and inspection results.




## Record Information

NAVFAC P-307 requires that the records include identification of individual components, latest test and inspection results, and dates of inspections and tests. There are many ways to identify the equipment to the records.

## Identifying Gear to Record

A unique identification number may be used to identify the equipment to its record. The ID number can be as simple or complex as you need it to be. A simple method might be to use a letter designator that represents a particular type of gear followed by a serialized number. For example, "S" could represent shackles. If you have 50 shackles they could each be individually identified S1, S2, S3, etc. Mark the equipment ID number on the gear. Write the ID number on the record. Now the gear has identifiable records.


Unique identification number
Letter designator followed by a number

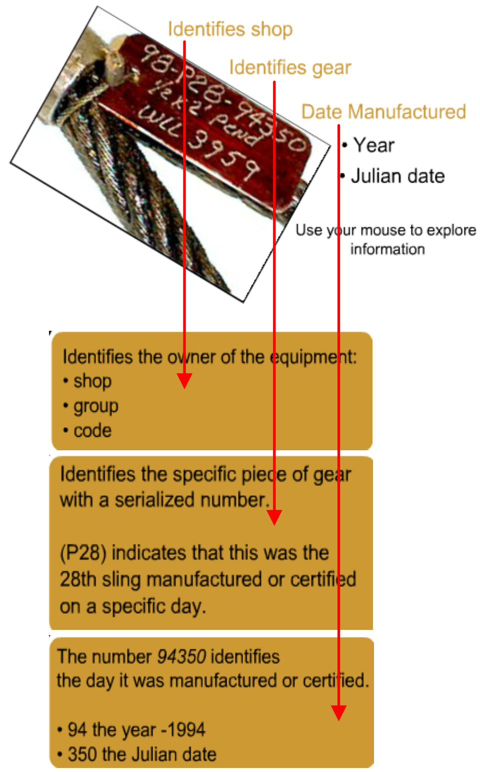
Example:
**S-27**
"S" represents *shackles*
27 individually identified shackle

## EXAMPLE: GEAR MARKING

This is an example of how the gear is marked at one Naval Shipyard. This is just one example of how an activity could choose to identify individual components to their records.

This example reflects a fairly complex system that may be useful for activities who own multiple groups of equipment that need to be segregated. In this example, the unique identification number is used to identify three different things. The first number “98” identifies which shop, group, or code owns the equipment. Secondly, “P28” identifies the specific piece of gear with a serialized number. This particular number indicates that it was the 28th sling manufactured or certified on a specific day. The number 94-350 identifies the day it was manufactured or certified, 94 being the year 1994, 350 being the Julian date. No matter what method you use, there is important information that should be included in the gears records.

**Gear Marking Example**



# NOTES

## RIGGING GEAR INSPECTION

### INSPECTIONS TYPES

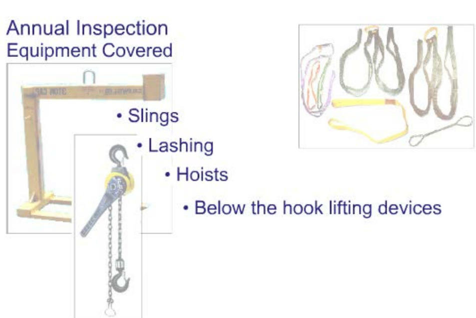
There are two types of required inspections, pre-use and periodic. The pre-use inspection is performed prior to use. No documentation is required for pre-use inspections. The periodic inspection is a comprehensive, documented inspection, performed on a schedule.

### PRE-USE INSPECTION

All equipment must be inspected prior to each use. The pre-use inspection ensures the equipment is not damaged or worn beyond allowable limits. The inspector must verify the rated load of the equipment and ensure the markings are legible. If the inspection due date has passed, the equipment must not be used. Remove any gear from service that fails inspection.


### PERIODIC INSPECTION

Periodic inspections must be done by a qualified person. If inspection reveals that the equipment has accumulated damage or is worn beyond the allowable limits it must be removed from service. Records must be kept on file for all periodic inspections. Inspection records provide a basis for evaluation, and provide the audit trail proving the equipment is in a test and inspection program. The inspection frequency varies depending on the type of equipment. See table 14-1 of NAVFAC P-307.




### ANNUAL INSPECTION

Periodic inspections are required every year for slings, lashing, hoists, equalizers, load indicating devices, container spreaders, personnel platforms, cranes integral to larger machine systems, and below the hook lifting devices.

## BIENNIAL INSPECTION


Periodic inspections are required every 2 years for rigging hardware such as beam clamps, tackle blocks, snatch blocks and wire rope blocks. Crane structures without permanent hoists are also included, as are: eye bolts, eye nuts, hook, links and rings, portable A-frames, portable gantries, portable floor cranes, shackles, swivels, swivel hoist rings and turnbuckles.

## QUARTERLY INSPECTION

In addition to the annual inspection noted previously, OSHA requires a periodic inspection every three months for chain slings used in ship repair and cargo transfer.

## SLING REJECTION CRITERIA: KNOTS

A knot in any part of a sling is cause for rejection.

## CHAIN SLING INSPECTION 1

Chain slings used for overhead lifting must be fabricated from chain that is grade 80 or 100. Links are randomly marked by the manufacturer with 8, 80, or 800 for grade 80 chain, and 10, 100, or 1000 for grade 100 chain.

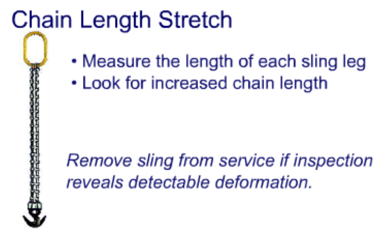


## CHAIN SLING INSPECTION 2

Chain slings are generally very tough and durable and consequently they tend to get a lot of hard use. Carefully inspect each link and end attachment; including master links and coupling links. Nicks and cracks may be removed by grinding. Measure the link or component after grinding. Rejection is required if the defect cannot be removed or if any part of the link diameter is below the required minimum. Look for deformation such as twisted, bent, stretched links, or broken welds.


## CHAIN LINK WEAR

Remove the sling from service if the thickness is below the value shown in NAVFAC P-307.

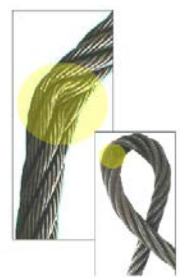



## CHAIN LINK STRETCH

Chain links stretch when they are overloaded. Worn chain links will also cause the sling length to increase. Measure the length of each sling leg and look for increased chain length that may indicate overloading or link wear.

## HAMMER LINK INSPECTION

Inspect hammer links carefully. Make sure the keeper pin is not loose or protruding.

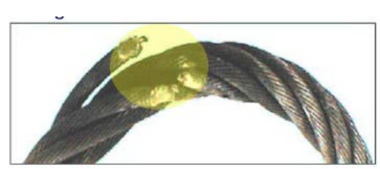


## WIRE ROPE SLING REJECTION CRITERIA 1

Inspect wire rope slings along the entire length of the sling including splices, end attachments, and fittings. Look for permanent distortion such as kinked, crushed, or birdcaged areas.

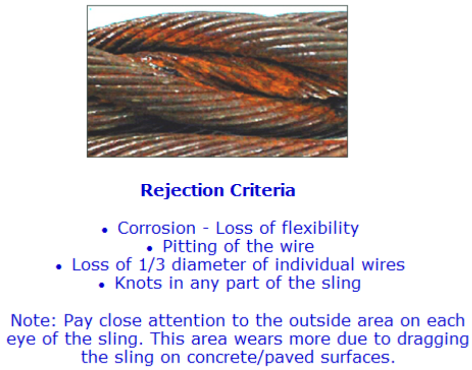
## WIRE ROPE SLING REJECTION CRITERIA 2

Look for core protrusion in-between the strands of the wire rope. Core protrusion is indicative of structural failure within the wire rope. The core should not be visible in straight runs. However, when a wire rope is bent, you will be able to see the core; this is not core protrusion. Fiber core wire rope slings may sometimes protrude between the strands in the end of an eye, opposite the bearing point; this too is not core protrusion.



## WIRE ROPE SLING REJECTION CRITERIA 3

Look for signs of heat damage such as discoloration and other more obvious signs as shown here.




## Wire Rope Sling Rejection Criteria 4

Look for severe corrosion or pitting of the wires or any condition that would cause loss of wire rope strength. Pay close attention to the outside area on each eye of the sling. This area wears more due to dragging the sling on concrete/paved surfaces.

## Wire Rope Sling Inspection: Measurement

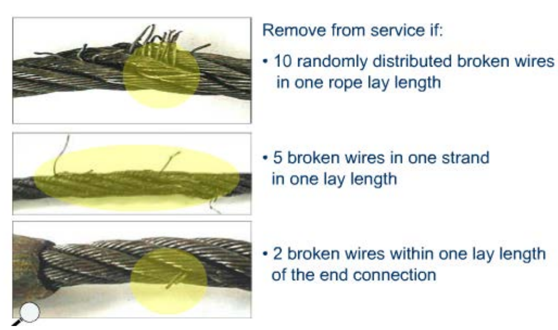
When measuring wire rope sling diameter with calipers, make sure you place the caliper on the crowns of the wire strands. Do not place the caliper across the flats or valleys of the strands.


## Wire Rope Sling Inspection: Broken Wires 1

Do not run your bare hand along the wire rope to detect broken wires! Bend the sling while watching for broken inside wires. Bending will open the area between the two ends and expose a broken wire making it easy to detect. Broken wire rejection criteria is based on a section of the wire determined by its “lay length”. Lay length is the linear distance along the wire rope in which a strand makes one complete turn around the rope's center.

## Wire Rope Sling Inspection: Broken Wires 2

Single part and strand laid wire rope slings must be removed from service if inspection reveals any of the following criteria, ten randomly distributed broken wires in one lay length, five broken wires in one strand in one lay length or two broken wires within one lay length of the end connection.



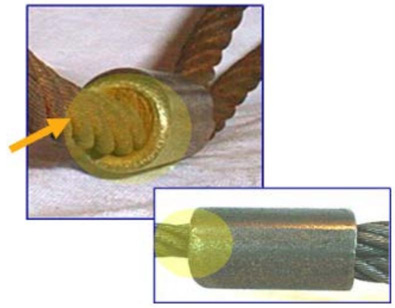

## WIRE ROPE SLING INSPECTION: BROKEN WIRES 3

For braided wire rope slings with less than eight parts, reject slings with 20 randomly distributed broken wires in one rope lay length, or one completely broken strand. For braided wire rope slings with eight parts or more, reject slings with 40 randomly distributed broken wires in one rope lay length or one completely broken strand.

## WIRE ROPE SLING INSPECTION: BROKEN WIRES 4

Cable laid wire rope slings must be removed from service if inspection reveals, 20 randomly distributed broken wires in one rope lay length, or one completely broken strand.

## WIRE ROPE SLING INSPECTION: END FITTINGS



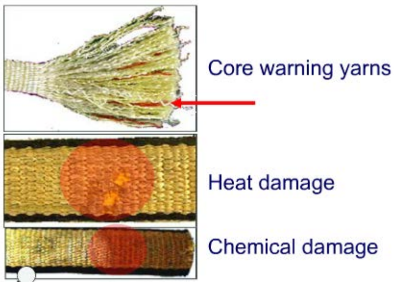
When inspecting slings with end fittings, ensure the fitting is not cracked, deformed or loose. Make sure the wire rope in the fitting is not corroded. Inspect the end attachment for wear that exceeds 10% of the OEM's nominal socket dimension or 5% of the socket pin diameter. When inspecting slings with speltered sockets, the wire should not have any axial or lateral movement.

## METAL MESH SLING INSPECTION 1

Inspect the entire length of metal mesh slings including welds, end attachments, and fittings. Remove the sling from service if inspection reveals a broken wire in any part of the mesh, a broken weld or broken brazed joint along the sling edge, reduction in wire diameter of 25% due to abrasion or 15% due to corrosion, lack of flexibility due to distortion of the mesh or any cracks in the end fitting.

## METAL MESH SLING INSPECTION 2

Remove the sling from service if the eye openings in the end fitting are increased by more than 10%, or if there is a reduction of 15% of the original cross sectional area at any point around the hook opening of the end fitting.

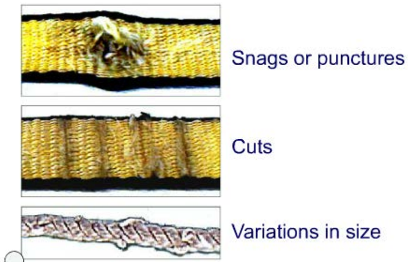


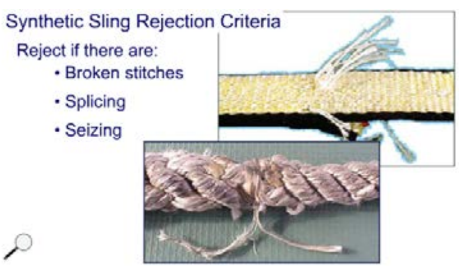

## SYNTHETIC SLING INSPECTION/REJECTION 1

Never use synthetic slings with exposed core warning yarns.  Do not rely on core warning yarns to indicate damage, as not all manufacturers use them and damage can reach rejection limits without exposing core yarns.

## SYNTHETIC SLING INSPECTION/REJECTION 2

Other damage that would require a synthetic sling to be removed from service includes heat or chemical damage, punctures, cuts, and variations in size, thickness or roundness of the sling.




## SYNTHETIC SLING INSPECTION/REJECTION 3

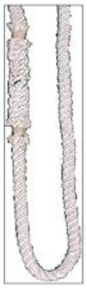
Look for broken or damaged stitches or splices.  The stitching holds the sling together. Check it carefully.

## SYNTHETIC SLING INSPECTION/REJECTION 4

Look for damage caused by prolonged exposure to sunlight, which can result in discoloration, fading or roughness.  Look for cracked, distorted, broken, or excessively worn, pitted, or corroded end fittings.  Also look for knots or indications the sling has been knotted. If you find evidence that a sling has been knotted, remove it from service.

## Synthetic Rope Sling Inspection

Remove from service if considerable fiber or filament breakage is found along the line where adjacent strands meet. Light fuzzing is acceptable. Look for powder or particles of broken filaments or fibers inside the rope between the strands.



Twist or pry the rope open for inspection. Inspect filaments or fibers for weakness, brittleness, or variations in the size or roundness of the strands.

## Synthetic Round Sling Inspection

Remove the sling from service if inspection reveals any of the following: melting, burn marks, charring, or other evidence of heat damage; snags, punctures, tears, or cuts that expose any part of the core yarns; broken or worn stitches in load bearing splices; excessive wear, abrasion, or embedded abrasive particles; internal knots, bumps, bulges, or irregularities that can be felt by massaging the sling manually along its length. Note: A knot in the yarn where the cover is joined may be a termination made by the OEM, which is acceptable.) Cracked, distorted, broken, or excessively worn, pitted, or corroded end fittings; and any other condition that causes doubt as to the strength of the sling are also signs for removing a sling from service.

Synthetic roundslings have two covers. If the outer cover is torn, cut, or damaged, the sling should be removed from service and sent to the OEM for inspection and repair. If the inside cover is also torn or damaged and exposing the core yarns, the sling must be removed from service.

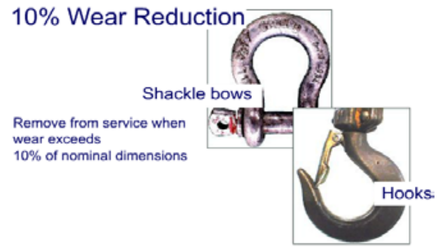

## Hardware Damage: Types

When inspecting rigging hardware look for corrosion or severe pitting that, when cleaned, would leave behind an orange peel effect. Slight surface rust is okay. Inspect for wear, cracks, nicks, gouges, deformation, or distortion. Distortion may include elongation, peening, or heat damage.

## Hardware Damage: Bearing Surfaces

Inspect the whole body of the hardware, but be particularly vigilant when inspecting the bearing surfaces for wear and distortion. Pay particular attention to the bearing surfaces since this is where the load is applied and will often show tell-tale signs of overload or abuse; just as the flattened area indicates on this picture.

## Hardware Damage: 10% Wear Criteria




Remove shackle bows and welded links, from service when wear exceeds 10% of the nominal diameter shown in federal specification RR-C-271. For shackle sizes not shown in federal specification RR-C-271, the OEM's listed nominal dimensions will be used. Remove hooks from service when wear exceeds 10% of OEM's nominal dimensions.

## Hardware Damage: 5% Wear Criteria

Remove weldless links, shackle pins, and swivels, from service when wear exceeds 5% of the nominal diameter shown in federal specification RR-C-271. For sizes not shown in federal specification RR-C-271, the OEM's listed nominal dimensions shall be used. Remove eyebolts when wear exceeds 5% of the OEM's nominal eye section diameter. Remove turnbuckles when end-fitting wear exceeds 5% of the OEM's nominal dimensions. Remove swivel hoist rings when wear exceeds 5% of the OEM's minimum dimensions.

## Hardware Damage: Threads

Threaded shanks must be inspected carefully before use or load testing. When using gear with threaded shanks such as eyebolts, hoist rings, etc., inspect the shank carefully for bends, twists, or damaged threads.

## Hardware Damage: Moving Parts

Some hardware has moving parts such as hoist rings and turnbuckles. Ensure that all moving parts move freely. Hoist ring bases should swivel 360° and the bail should pivot at least 180°.

## Tackle Blocks

Tackle blocks shall be removed from service if inspection reveals distortion, cracks in the housing or sheaves, damaged sheaves, binding, abnormal sheave play, or any damage that may cause doubt as to the strength of the unit.

## Below-the-Hook Lifting Devices


Below the hook lifting devices and container spreaders shall be inspected in accordance with ASME B30.20 and OEM recommendations.  Always read and follow the information provided by the OEM.

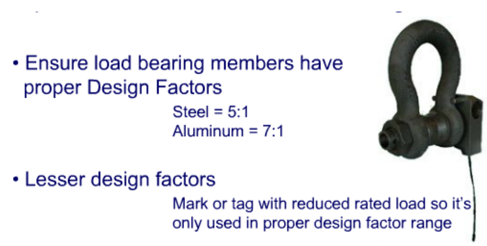
## Hoists, Cranes, A-Frames, Gantries

Chain hoists and portable hoists shall be inspected in accordance with: ASME B30.16 and OEM recommendations.

Lever operated hoists shall be inspected in accordance with ASME B30.21 and OEM recommendations.

Other equipment shall be inspected in accordance with applicable ASME B30 criteria and/or OEM recommendations.

## Load Indicating Devices



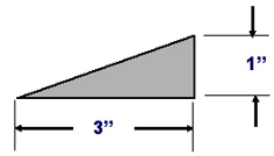

Check for visible damage and any other attributes listed by the OEM.  Portable load indicating devices shall only be used in the range that ensures the proper design factor.  Ensure they are marked or tagged to indicate the reduced maximum rated load, if required.

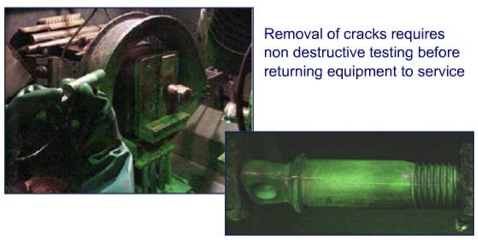
## Repairs

When minor damage, such as nicks or cracks are found, it may be possible, and more economical, to remove the defect rather than replace the gear.  Repairs must be performed in accordance with OEM or engineering instructions.  Alterations must be approved by the activity engineering organization.  Re-inspection and load test of the repaired or altered equipment shall be performed prior to returning to service.  Repair documentation for load bearing, load controlling, or operational safety devices must be retained for 7 years, all other repairs 1 year.  Alteration documentation must be retained for the life of equipment.

## AUTHORIZED REPAIRS

Grinding to remove defects is the only method authorized to repair rigging gear. Heat or welding is not permitted to correct defects. And no attempt shall be made to straighten bent or twisted rigging gear. Grinding shall follow the contour of the piece, blending with a maximum 1 to 3 taper. The component dimensions after grinding must be within the wear limits for the piece being repaired. If the after-grinding dimensions exceed the wear limits specified by the OEM or NAVFAC P-307, the component must be removed from service. Removal of defects as specified will not require a load test.




## NON-DESTRUCTIVE TESTING

Removal of cracks must be verified by non-destructive testing before the hardware can be returned to service.

# NOTES

## Rigging Gear Test Requirements

### Load Testing

There are two types of load tests described in NAVFAC P-307. The first is a static load test. In a static test the load is held for a specified amount of time to determine if the equipment will hold the load. The second test is a dynamic test. In a dynamic test the load is applied and the equipment is operated through a complete cycle of all its moving parts. Dynamic tests are performed under load to insure the equipment operates properly, to check brake mechanisms, and to observe for indications of improper operation such as unusual noises or binding.

### Static Test

Load tests ensure that the equipment will operate safely within its rated load and design function. All covered equipment must be static tested with the equipment holding the test load for a minimum of 2 minutes. Hoist, crane, and crane structure static tests must be held for 10 minutes. No permanent deformation should be found

### Dynamic Test

Equipment with moving parts requires an additional test. Hoists, trolleys, and other moving machinery are required to have a dynamic test in addition to the static test. They must lift, or travel, through at least one revolution of all moving parts with the test load applied.

### Initial Load Test

Each piece of covered equipment must have an initial load test. A manufacturer's certificate of proof test will satisfy this requirement as long as the proof load meets or exceeds the load specified in NAVFAC P-307. Certificates of proof tests for alternate yarn roundslings must include the diameter of the pin used during test. Any material other than nylon or polyester used to fabricate a roundsling is known as an alternate yarn.

### Determine Test Load

To determine the correct test load, you will need to know the rated load of the equipment and the required test percentage. Load test percentages for rigging gear and related equipment can be found in Table 14-1 of NAVFAC P-307. Be sure to check the test load percentage for the type of gear you are testing as different types of gear are tested at different percentages.

**Determining Test Loads**

- Find rated load
- Find test percentage in Table 14-1
- Make a few calculations

## TEST LOAD TOLERANCE

The test load tolerance is plus 5% and minus 0%. The plus 5% provides a range to ensure the full test load is achieved without excessive overloading.

**Test Loads (+5% - 0% )**

- Establishes minimum and maximum test load
- Ensures load is not under minimum value
- Ensures load does not excessively overload equipment

Keep as close to minimum as possible!

**Determining Test Load - Step 1**

Finding minimum test load:

- Rated load 2,000 lbs
- Test percentage 125%

1.25 x 2,000 = 2,500 lbs
Test load must not be under 2,500 lbs!

## DETERMINING TEST LOAD: STEP 1

To find the minimum test load for a plate clamp with a rated load of 2,000 lbs. we must first find the required test load percentage in Table 14-1 of NAVFAC P-307. We see the plate clamps are tested at 125%, plus 5%, minus 0%. Multiply 2,000 pounds by 1.25. This equals 2,500 lbs. The test load must not be less than 2,500 lbs.

**Determining Test Load - Step 2**

Finding +5% load tolerance:

2,500 lbs. x 1.05 = 2,625 lbs

Test load must not be more than 2,625 lbs!

## DETERMINING TEST LOAD: STEP 2

Once the minimum test load is established we need to determine the load tolerance. Multiply the 2,500 lbs. minimum test load by 1.05. This equals 2,625 lbs., the maximum test load for this piece of equipment.

## TEST LOAD EXCEPTION

Where the OEM does not allow testing at the required test percentages, the OEM's rated load will be used as the load test value.

## RATED LOAD REDUCTION

For example, if we need to load test a plate clamp that has a rated load of 2,000 lbs. and the OEM does not allow overload testing, 2,000 lbs. will be used as the test load. Because the test load has been reduced we must also reduce the rated load. To find the reduced rated load divide the OEM's rated load by the test load percentage. So we divide the OEM rated load of 2,000 lbs. by 1.25 and find the reduced rated load is 1,600 lbs. The item must be marked to show the new rated load.

**Rated Load Reduction**

2,000 lbs. becomes maximum test load

- Items requiring 125% test loads:
  - OEM rated load *divided by* 1.25
  - 2,000 ÷ 1.25 = 1,600
- 1,600 lbs is new rated load
- Items requiring 150% test loads:
  - 2,000 ÷ 1.50 = 1,333

### Conducting Load Tests

When conducting load tests, wear the appropriate personal protective equipment and secure the area to keep personnel out of harm's way in case the equipment fails. Remember, you are exceeding the rated load of the gear. Be safe!

### Specific Requirements

Many requirements are specific to the type of equipment being tested. Rigging assemblies must be tested with all of the parts together as a complete assembly. The components may not be used separately unless each component was individually tested to the requirements of NAVFAC P-307.

### Multiple Leg Slings

When testing multiple leg slings the legs may be tested individually; or they may be tested two at a time with the legs 180° apart. Master links and master coupling links must be tested to the test load required for each individual sling leg multiplied by the number of sling legs. Activities may choose to size the master links assuming only two legs will carry the load. In that case the test load will be two times the test load of an individual leg.

### Lashing

Lashing materials such as synthetic rope, wire rope, and webbing do not need to be individually tested if a sample has been tested and each piece is marked. A sample

from each spool or reel must be tested and determined to have satisfactory breaking strength. OEM certification is acceptable. Each piece used for lashing must be inspected and marked.

### Annual Load Test

A periodic load test must be conducted annually, or within 12 months prior to use on manual and powered hoists, magnetic and vacuum lifting devices, personnel platforms, plate clamps and cranes and hoists that are integral to larger machine systems.

## CONTROLLED STORAGE

The requirement for periodic load test within 12 months prior to use does not apply to manually operated portable hoists placed into an extended controlled storage condition. The hoist must be inspected, repaired if necessary, and initially load tested. It may then be placed in controlled storage and given a tracking number. A numbered metal locking band must be applied to the pull chain or operating lever to ensure the hoist cannot be operated. When the hoist is needed for use, it must be visually inspected for apparent damage or significant deterioration and operated prior to being issued. The inspection due date must then be marked on the hoist. This new inspection date cannot exceed one year from the date the hoist was put back into service.

## BIENNIAL LOAD TEST

Crane structures without permanently attached hoists, as well as portable A-frames, portable gantries, and portable floor cranes, are required to be tested every 2 years.

## COMMON RIGGING GEAR

All common rigging equipment like slings, shackles, hooks, rings, links, and eyebolts purchased after January 1998 require a one time load test of 200%. A certificate of proof test from the equipment supplier satisfies this requirement. Certificates must be retained on file.

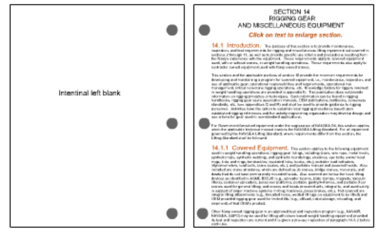
## BELOW-THE-HOOK LIFTING DEVICES

Container spreaders and below the hook lifting devices shall be tested in accordance with Section 14 of NAVFAC P-307.

# NOTES

## Rigging Gear General Use

### NAVFAC P-307 Section 14
NAVFAC P-307 provides specific rules for using rigging equipment described in section 14. It does not, however, provide specific direction on rigging practices or techniques.





### Rigging Manuals
Information on rigging techniques can be found in rigging handbooks, rigging manuals, OEM publications, textbooks, and consensus standards. Let's cover some of the safety precautions that apply to all types of rigging equipment or operations.

### General Safety Rules
Remain alert when performing crane rigging operations. Hazards are always present. Two common danger areas are between the rigging gear and the load; and between the load and other objects. These areas are sometimes referred to as "the bight". Be sure to your keep hands, feet, and head, out of the bight.

### Shop-made Gear
Never use shop made equipment unless it has been approved by engineering and certified for use in weight handling operations.

### Selection 1
Use rigging gear only for the purpose it is designed for.

Rigging gear is a tool like a hammer or wrench. We've all heard the phrase…

"use the right tool for the job."

It's the same for rigging gear. If you don't have the right rigging gear to safely do the job, stop and get it. Never use damaged gear. Never use gear past its inspection due date. Your safety and the safety of the rest of the crane team depend on the gear you use, and how you use it.

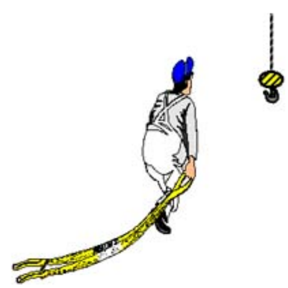
Take the time to do it right!

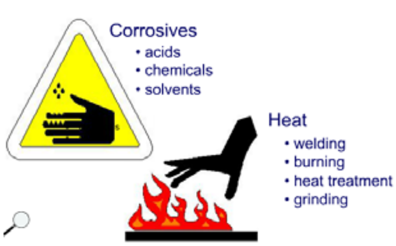
## SELECTION 2

Keep the following in mind when selecting rigging equipment. Rigging equipment must be selected based on the total force that will be applied to the gear, not just the weight of the load. Remember, in some cases, the force in one leg of a multiple sling leg could exceed the weight of the load. Keep the overhead height restrictions or clearances in mind when selecting sling length. Sling lengths that are too long may cause the hook to reach the limit switch before the load reaches the desired height. You must also think about the hazards the gear may be subjected to so you can choose the appropriate equipment.

## HAZARDS 1

The first major hazard we must talk about is abuse. Here the biggest hazard is you, the user! Don't drag your slings on the ground. Cement or paved surfaces will quickly abrade slings and gear. Contact with the ground can embed grit and abrasives into the sling, which will cause damage. Don't pull slings from under a load while the load is resting on them. Set the load down on blocking to keep from crushing the sling.






## HAZARDS 2

Keep gear away from corrosives, acids, paint thinners, and any other harmful chemicals. Chemicals that may have a corrosive effect on one type of gear may not affect another. For example, acids would quickly destroy a nylon sling but might not harm another synthetic material. Protect your gear from all heat sources such as welding, burning, grinding, or heat-treating.

## HAZARDS 3


Another common hazard is sharp edges. No matter what type of gear you use, sharp edges will leave their mark if the gear is not protected. Never use slings against sharp edges without adequate protection.

## HAZARDS 4

You must be aware of the danger electricity presents when working around energized components or electrical lines. Watch out for welding leads, light strings, shore power and other common hazards when looking for lay down areas. Wire rope, chain, and metal mesh slings should never be used if they could increase the possibility of electrical shock. Protect yourself and the gear by ensuring all power is secured prior to installing your gear on or around electrical components.

## PROTECTIVE MATERIALS

So how do we protect our gear from being damaged by sharp edges? It's necessary to use protective materials, known as "chafing gear," to prolong the life of our rigging gear and items being lifted. Chafing gear can be any material used for protecting rigging gear or loads. Chafing gear increases friction thereby reducing the tendency for rigging to slip. Wood blocks, canvas, cardboard, rubber, leather and old fire hose are great for protecting critical or machined surfaces and increasing friction. These are just a few examples of chafing gear.

## USING CHAFING GEAR

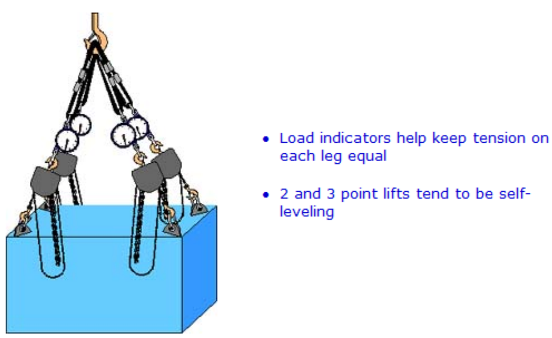
Chafing gear can be many types of materials and it may be used many different ways. Wood blocks may be used to keep slings away from sharp edges. Old fire hose can be placed between your gear and sharp edges or a sling can be passed through the hose and used as a protective sleeve. Remove the hose to inspect for damage before and after each use. hose can hide sling damage if left on the sling!

## Hoist & Crane References

Portable floor cranes, portable a-frames, portable gantries, and cranes integral to larger machine systems must be operated in accordance with applicable ASME B30 criteria and OEM recommendations. Chain Hoists and portable hoists must be operated in accordance with ASME B30.16 and OEM recommendations. Lever operated hoists must be operated in accordance with ASME B30.21 and OEM recommendations. Other applicable equipment must be operated in accordance with ASME B30 and OEM recommendations.

## Using Hoists & Cranes

When using chain hoists and portable floor cranes, ensure hoist capacities meet or exceed the expected load. Load indicating devices may be used to help prevent overload of the hoist and related gear when leveling, rotating, or tilting objects.

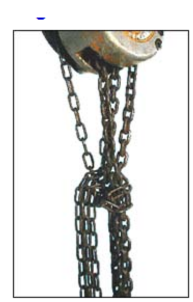



## Using Hoists to Distribute Sling Loading

When chain hoists are used to equalize a load at four or more points, they must be used in conjunction with load indicating devices.

## Hoist Operation Do's

Secure hand chain and excess load chain to prevent tangling and inadvertent operation. A bag can be attached to the hoist body to hold excess chain. Never use more than one person to pull the hand chain of a manual chain hoist. Do not use excessive force to operate a hoist. Never use extension bars on lever-operated hoists.




## HOIST OPERATION DON'TS

Never use the load chain to choke around an object and never "tip load" the hook!

## BELOW-THE-HOOK LIFTING DEVICES

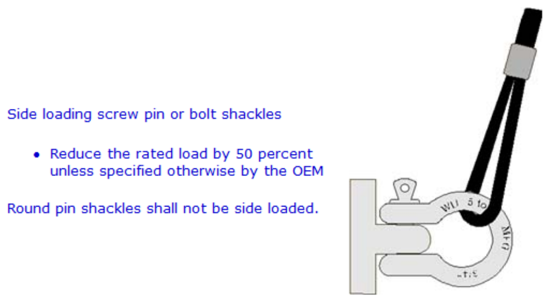
Below the hook lifting devices and container spreaders must be operated in accordance with ASME B30.20 and OEM recommendations. Never use below the hook lifting devices if you do not thoroughly understand the operating characteristics and limitations. Ensure the lifting device has sufficient capacity for the expected load.

# NOTES

## RIGGING HARDWARE

### HARDWARE USAGE

Use the same size and type of shackle on each leg in multiple leg applications. Different types, sizes, or brands of shackles may vary significantly in physical size. This in turn will affect the overall length of the leg and the tension created in each leg. When installing the pin into the bail, be sure the pin is fully seated into the bail.


### SIDE LOADING SHACKLES

It may be sometimes necessary to apply a side load to a shackle. When side loading a screw pin or bolt type shackle reduce the rated load by 50% or as specified by the OEM.

### EYEBOLT TYPES

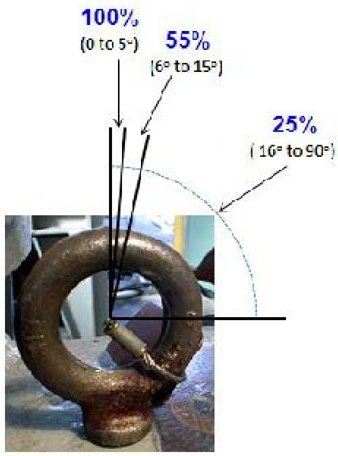
There are two types of eyebolts you may find at your work site, shouldered eyebolts and non-shouldered eyebolts. Non-shouldered eyebolts are sometimes referred to as plain pattern or regular nut eyebolts. All eyebolts must be used in accordance with OEM instructions.


### NON-SHOULDERED EYEBOLTS

Non-shouldered eyebolts may be used in vertical applications only. Angled pulls greater than five degrees, even in the plane of the eye are not permitted.

## SHOULDERED EYEBOLTS

Shouldered eyebolts may be loaded at an angle as long as they are loaded in the plane of the eye. When loading a shouldered eyebolt at an angle, the capacity of the eyebolt is reduced.




## INSTALLING SHOULDERED EYEBOLTS

When loading shouldered eyebolts at an angle in the plane of the eye, the eyebolts must be installed with the shoulder seated flush against the mounting surface.

## ENGAGING HOLE REQUIREMENTS

When checking the engaging hole in the item you are going to lift: Make sure the threads are not damaged and the hole is free of debris.

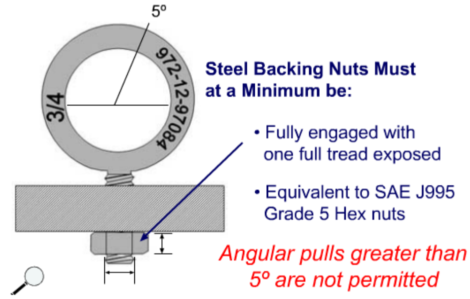

## THREAD ENGAGEMENT

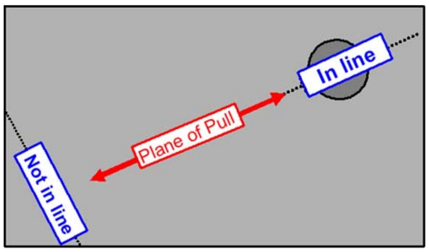
The minimum thread engagement depends on the material into which you are installing the piece of rigging equipment. When installing eyebolts into steel the minimum required thread engagement is one and one half times the diameter. When installing eyebolts into aluminum, the minimum thread engagement is two times the diameter. For other materials contact your activity's engineering organization or the OEM.

## BACKING NUTS

When eyebolts are used with backing nuts, the backing nut must be at least SAE grade five and fully engaged with at least one full thread exposed.

Note: With engineering approval, nut type eyebolts can be used without the shoulder being flush.



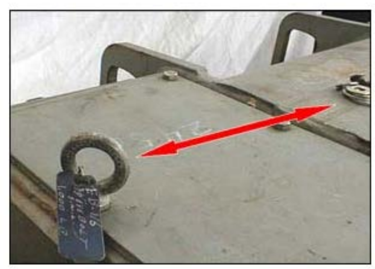




## EYE ALIGNMENT

To use eyebolts with an angular load, the loading must be in line with the plane of the eye. This may not always happen when installing eyebolts. Look at this shape and imagine two slings connected to each eyebolt shown from the top. You can see that the top eyebolt would be in line with the plane if two slings were attached. The bottom eyebolt ended up out of plane when tightened against the seating surface.

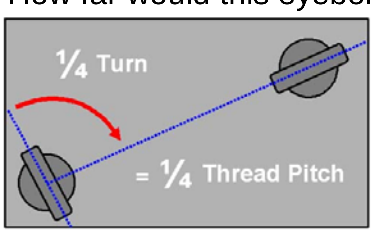
## SHIM USAGE

To remedy this, shims may be used to align the eye with the plane of the pull. When using shims, use the minimum thickness that will orient the eye the plane of the pull. The total thickness of shims must never exceed one thread pitch. The thread pitch represents one full revolution or rotation of the shank. If there are 16 threads per inch, then the thread pitch is 1/16th inch.



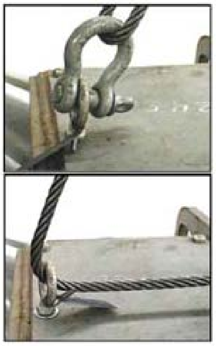
## DETERMINING SHIM AMOUNT

In order to determine shim thickness we must determine how much rotation is required. How far would this eyebolt have to rotate in order to line up in the plane of pull? It must rotate 1/4 of a turn. How much shim would that require? One quarter of the thread pitch would orient the eyebolt in line to the plane of pull. For the eyebolt noted previously with a thread pitch of 1/16th inch, total shim thickness would be 1/64th inch.



## Incorrect Use of Shims

This is an example of shims being used incorrectly. Do you see the problem with this eyebolt installation? The total shim thickness is more than the thread pitch.



## Side Pulls

Side pulls on eyebolts are very dangerous and may cause the eyebolt to fail. Side pulls result from loading out of the plane of the eye. Never install a sling through two separate eyebolts. The result will be side pulls on both eyebolts and damage to the sling.

## Eye Nuts

Eye-nuts must be used in accordance with OEM instructions. They must have full thread engagement. This means the shank or stud they are attached to must be long enough to allow complete engagement of the eye-nut. Eye-nuts must be used for vertical applications only.

## Swivel Hoist Rings 1

Angular pulls do not reduce rated load of a swivel hoist ring. When using swivel hoist rings, they must be installed with the shoulder flush with the mounting surface. They must be tightened with a calibrated torque wrench in accordance with OEM requirements. Check the OEM instructions prior to installing any shims. Most manufacturers do not allow the use of shims with swivel hoist rings.

- Angled pull does not reduce rated load
- Install per OEM instructions


## Swivel Hoist Rings 2

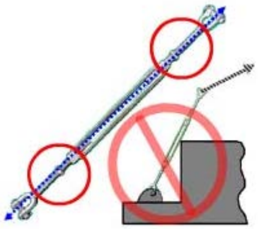
Swivel hoist rings must be used in accordance with OEM specifications. They must be tightened to the OEM specified torque. The torque value is normally marked on the top washer of the hoist ring. Before using backing nuts on hoist rings, check the OEM specification to see if it is allowed.

### TURNBUCKLES 1

Turnbuckles are commonly used for tensioning lines and securing loads but may be used for crane rigging if they meet the test, inspection and certification requirements of NAVFAC P-307.

### TURNBUCKLES 2

Turnbuckles are used only for in-line pulls. Jam nuts, when used, must be tightened in accordance with OEM instructions to prevent rotation. If the possibility of rotation still exists, the turnbuckle must be secured by safety wire or other suitable means in addition to jam nuts.



### THREADED ATTACHMENT POINT WARNING

Remember to use extreme caution when using a threaded item such as an eyebolt or a hoist ring as a single attachment point. Never rotate or spin an object being lifted with a single threaded attachment point. The lifting attachment may unthread and the object may fall.

# NOTES

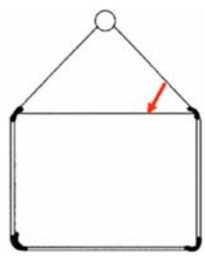
## SLING USE

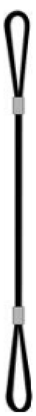
### WIRE ROPE SLING USE

A common metal sling is the wire rope sling. Wire rope slings have some limitations even though they are generally strong and durable. D-to-d is the term for the ratio between the diameter of the object around which the sling is bent and the diameter of the sling body. The capitol D represents the diameter of the object and the small d represents the diameter of the sling. When using wire rope slings always maintain a minimum D-to-d ratio of one to one in the body of the sling. In other words, Never bend a wire rope around a diameter smaller than itself! Bending a wire rope around a diameter smaller than its minimum D-to-d ratio will damage the wires and weaken the sling.

### WIRE ROPE: CHAFING PROTECTION

For loads with a non-circular cross section the bend diameter is derived from the minimum bend diameter of the wire rope around the corner of the load. For slings bent around corners, the corners must be rounded to provide the minimum D/d efficiency. Chafing protection is used to protect the load and sling from damage.



### WIRE ROPE: TEMPERATURE RESTRICTIONS

Wire rope must also be protected from extreme temperatures, which can seriously affect the wire's strength. Do not use wire rope slings below minus 40 degrees or above 400° Fahrenheit. Fiber core rope wire should not be used above 180° Fahrenheit.

### WIRE ROPE: CLIP/KNOT RESTRICTIONS

Wire rope clips should not be used to fabricate slings. Wire rope slings should never be knotted.

Never use wire rope clips on slings!

## CHAIN SLINGS

Chain slings are a good choice when the job demands abrasion and damage resistant slings. However, if used improperly, they too can be damaged. Chain slings should not be used on loads that are damaged easily. Never use knots or bolts to shorten or extend the sling. Use chafing on sharp corners and edges to prevent damage to slings and load. Always check OEM instructions for the chain sling you are using.

## CHAIN SLING: TEMPERATURE RESTRICTIONS

NAVFAC P-307 requires that chain slings should not be used when temperatures are below minus 40° Fahrenheit. When chain slings are used at or above 400° Fahrenheit, follow OEM recommendations.

## METAL MESH SLINGS: TEMPERATURE RESTRICTIONS

Metal mesh slings are often used in abrasive or high temperature environments that would damage slings. Do not use bare metal mesh slings when temperatures are below -20° or above 550° Fahrenheit. Do not use elastomer coated slings when temperatures are below 0° or above 200° Fahrenheit. Always follow OEM recommendations.


## SYNTHETIC SLINGS: TYPES

Synthetic slings should be used only when they can be protected from damage! Natural fiber rope slings are not to be used for overhead lifting.

## SYNTHETIC SLINGS: GENERAL REQUIREMENTS

Synthetic slings cannot be substituted for other slings specified on rigging sketches. Avoid chemical exposure to synthetic slings and always use chafing gear! Minimize exposure to sunlight and other sources of ultraviolet light. Store all synthetic slings indoors in a cool dry place. Always follow OEM recommendations when using synthetic slings

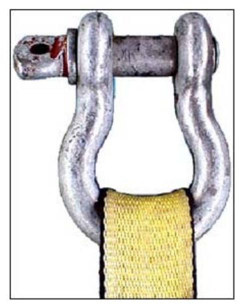
- No substituting for slings specified in work document
- Avoid chemical exposure!
- Always use chafing gear!
- Minimize exposure to sunlight
  - Store slings indoors

## SYNTHETIC SLINGS: KINKS, TWISTS, D/d

Web slings must be installed flat around the load without kinks or twists. Kinks and twists reduce friction on the load and can cause the sling to roll or slide out of position. These slings are not affected by D-to-d ratio. Eye length in relation to the diameter of the hook is critical. The eyes of webbing slings are stitched and the stitching can be damaged if the eye is spread excessively.

## SYNTHETIC SLINGS: SHACKLE USE

Shackles used with synthetic web slings must allow the sling to lay relatively flat without excessive curling of the edges. Curling causes uneven loading of the sling. Slight curling, however, is acceptable.



**Synthetic Web Sling Temperature Restrictions**

- Do not use above 194° F
- Follow OEM recommendations

## SYNTHETIC SLINGS: TEMPERATURE RESTRICTIONS

Do not use synthetic web slings at temperatures above 194° Fahrenheit or OEM recommendations, whichever is more restrictive.

## SYNTHETIC ROPE SLINGS: SPLICES AND D/d

When making single point lifts with eye and eye synthetic rope slings, use two slings or double up a single sling. These slings are hand spliced. If they are allowed to spin, the splice could come undone and drop the load! The minimum D-to-d ratio is 1 to 1. This means a one half-inch diameter synthetic rope sling cannot bent around any object that is smaller than one half-inch.


## SYNTHETIC ROPE SLINGS: TEMPERATURE RESTRICTIONS

Do not use nylon or polyester synthetic rope slings at temperatures above 194° or under minus 40° Fahrenheit. Do not use polypropylene slings at temperatures above 140° or under minus 40° Fahrenheit.


## SYNTHETIC ROUND SLINGS: USE

For roundslings, NAVFAC P-307 recommends that you use the shackle types listed by the OEM. Alternate yarn synthetic round slings must not be used around items smaller in diameter than the pin used to test the sling. The minimum D-to-d ratio shall be marked on all alternate yarn round slings.

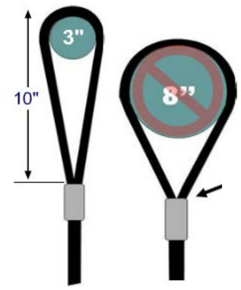
## SYNTHETIC ROUND SLING: TEMPERATURE RESTRICTIONS

Follow OEM recommendations when using roundslings in extreme temperatures.


## Common Rules

Slings must not be used at angles less than 30° from horizontal unless specifically authorized by an engineering work document. Never use a sling that has been knotted. Chafing gear should be used where needed. Rigging gear including slings, shackles, turnbuckles, and eyebolts, must be sized such that two legs can carry the load to allow for variations in sling length and load flex.

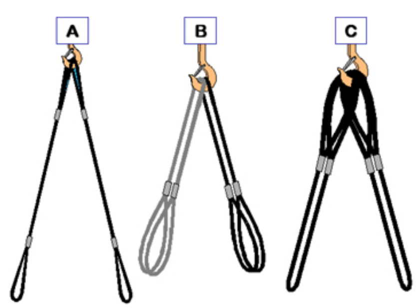
## Eye Length vs. Hook Diameter




The size of the hook or shackle relative to the size of the sling eye can be critical. If we place a ten-inch long sling eye on a load which is 3 inches in diameter, the eye opens slightly and causes very little added stress to the eye or the splice. However, if we place that sling on a hook with a diameter of 8 inches, this can stress the eye and can cause the swage or stitches to fail. Never place the eye of a wire rope sling around an object which has a diameter greater than 1/2 the length of the eye. Never place the eye of a synthetic web or rope sling around an object which has a diameter greater than 1/3 the length of the eye. If the hook diameter is too large, a shackle can be used to connect the slings to the hook, thereby reducing the diameter over which the sling eyes are placed.

## Attaching Slings to a Hook

When attaching rigging gear to hooks be sure the safety latch is working properly and closes the throat opening without obstruction. Failure to do so can allow the gear to come off the hook. All gear attached to the hook must seat properly in the bowl. Do not stack slings or allow slings to cross each other in the hook. That can lead to crushing of the slings!

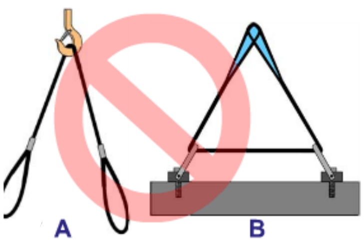



## Correct Sling-to-Hook Arrangement

These graphics illustrate correct ways to attach slings to a hook. Graphic “A” shows a vertical application with two sling eyes seated in the bowl of the hook. Graphic “B” shows two slings doubled over the hook and sling eyes pointing down to attachment points. Graphic “C” shows two slings doubled with sling eyes on the hook and the bight pointing down to attachment points. When wire rope slings are used as in graphics "B" and "C", and a heavy load is applied, individual wires may become permanently deformed or bent. If a sling is doubled to the point where it is permanently set, it should not be used in a vertical or straightened out configuration because straightening the sling could cause the wires to break in the strands.

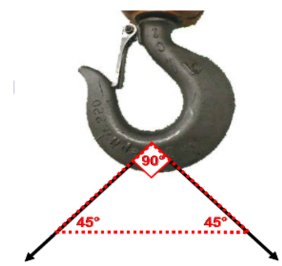
## Incorrect Sling-to-Hook Arrangement

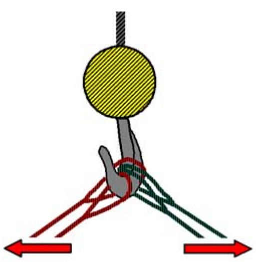
These graphics illustrate some incorrect ways of attaching slings to a hook. Incorrect sling applications can be extremely dangerous and can result in loss of load control and personnel injury! Graphic "A" shows a single sling with the "bight" riding the hook and the eyes attached to two separate attachment points. Slings applied in this manner could slip on the hook causing the load to shift. Graphic "B" shows a sling through two attachment points. Installing a sling through more than one attachment point will create excess stress on the sling, the attachment points, and the gear.




## Included Angle

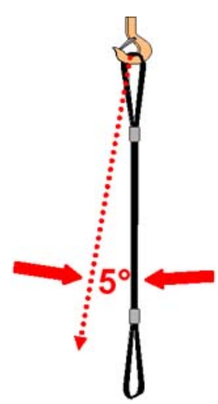
Included angle is the angle measured between two slings sharing a common attachment point. To prevent tip loading when lifting with two slings, the included angle created by slings attached to the hook must not exceed 90°. If the horizontal angle of the slings is less than 45°, the included angle will exceed 90°. In this case, you must use a shackle or other collection device to connect the slings to the hook.



## Inside-Outside 4-Sling-to-Hook Arrangement

When rigging four slings to a hook, separate the slings into two pairs, inside and outside so they do not pull in the plane of the hook. Attach the inside slings to one end of the object and the outside slings to the other end, being careful that they are not crossed.



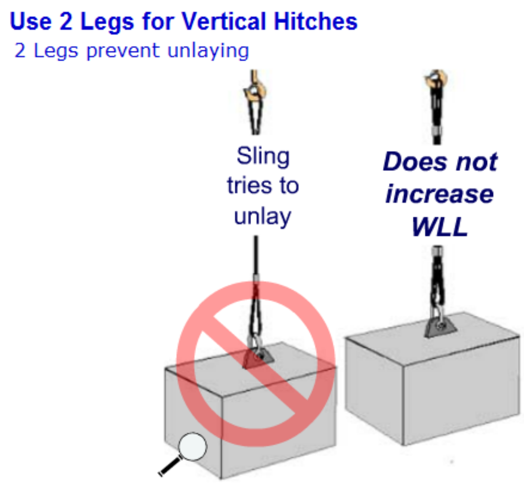

## Hitches: Types

Slings are used in three types of hitches: the vertical hitch, the choker hitch and the basket hitch. The rated load for the same sling with each hitch will be different.

## VERTICAL LOADING VS. ANGLED LOADING

The rated load for a vertical hitch is 100% of the sling's capacity.

Sling angle stress is encountered any time the vertical angle exceeds 5° and must be taken into account.




## VERTICAL HITCH SINGLE LEG CAUTION

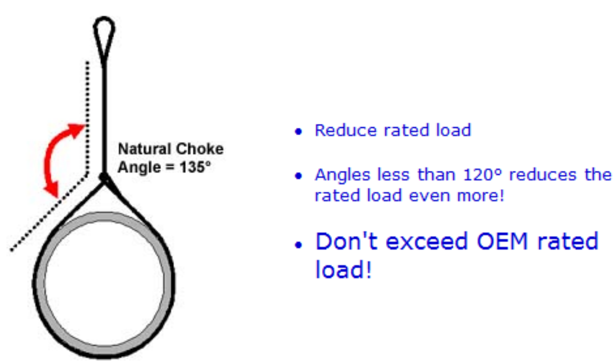
To prevent un-laying of the wire rope, do not use a single wire rope sling in a vertical hitch. Use two legs for single point lifts. The second leg prevents the sling from spinning. It is important to note that the configuration shown here does not increase the rated load because slings are rarely the exact same length. The shorter of the two will carry the load.

## CHOKER HITCHES & SHACKLES

Using a shackle to set a choker hitch will prolong the life of the sling. Whenever a shackle is used to set a choker hitch set the eye of the sling on the pin of the shackle. This will prevent the "running" part of sling from rotating the pin of the shackle as it passes over it. Never set the choker so the running part of the sling passes against the shackle pin.

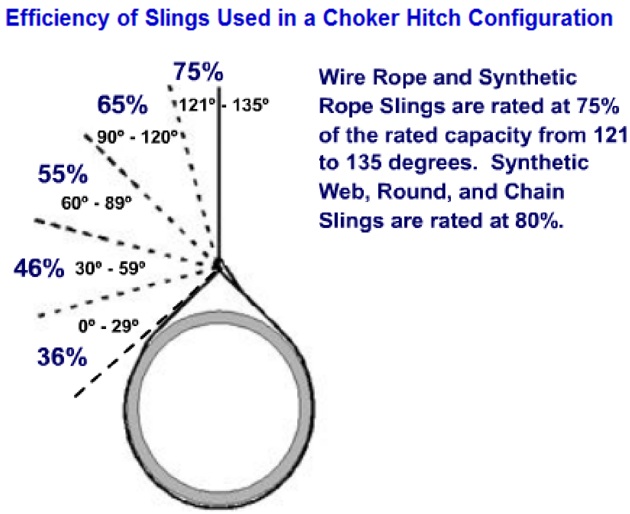
## CHOKER LOADS

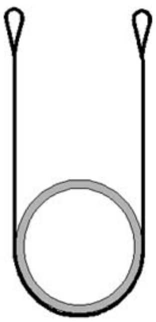
Whenever a choker hitch is used the sling's rated load is reduced. The natural choke angle is 135°, if a choker hitch is allowed to tighten itself as the load is lifted. When choke angles are less than 120° the rated load must be reduced further.



### CHOKER HITCH EFFICIENCY

This chart shows the efficiency of the sling's capacity when choking with a wire rope or synthetic rope sling. Refer to NAVFAC P-307 Table 14-4 for choker efficiencies of other slings. For angles 121° to 135°, the rated load is reduced to 75% of the vertical capacity. This does not apply to braided multi-part wire rope slings.



### BASKET HITCHES

Basket hitches are the strongest of the three hitches. Slings in a basket hitch can carry 200% of the sling's single rated load when the sling angle is less than 5° from vertical, and the required D-to-d ratio is maintained. Wire rope requires a D-to-d ratio of greater than 40 to 1. Synthetic rope requires a D-to-d ratio of at least 8 to 1.

# NOTES

## Crane Communications

### Communication Methods

Standard hand signals provide a universal language, understood by everyone involved with weight handling. Consequently, they are the most common method used in crane operations. When presented properly, standard hand signals help prevent miscommunication and play a very important part in safe crane operations. Radio communications are well suited for blind and complex lifts. As a general rule, direct voice should only be used when the operator and rigger are working in close proximity and ambient noise is not a factor.

- Hand signals
- Radio communications
- Direct voice
- Continuous communications required for
  - Complex lifts
  - Blind lifts
- Use direct voice only in close proximity

### Hand Signals

Hand signals are most widely used method of communication between signalers and crane operators. Hand signals like those found in the American Society of Mechanical Engineers, (ASME) B30 standards must be posted in the crane in clear view of the operator. Your activity may approve local signals in addition to these standard signals.

**Additional hand signals, must be**

- Approved by crane and rigger supervisors
- Included in rigger and operator training
- Posted in crane cab in clear view

**Relay Signalers:**

- From signaler to signaler to the operator
- Results in lag time
- Not more than two signalers
- Not recommended for close tolerance lifts
- Requires positive transfer of load control

### Signalers

Signalers must remain in clear view of the crane operator. If the crane operator can't see you, another method of communication must be used. Only one signaler communicates with the crane operator at a time.

**Hand Signaling Rules**

- Signal chart must be posted in clear view of the operator
- Maintain eye contact with the designated signaler
- Small movements will be indicated prior to signaling
- Only one signaler communicates with the crane operator at a time

## RADIO

Radios can be used to direct crane lifts while keeping crane team members informed of the lift status.

### Radio guidelines

The device, or devices, used shall be tested on-site prior to crane operations. Use an isolated channel and clear the line of other traffic. Limit background noise. The operator's reception of signals shall be by a hands-free system

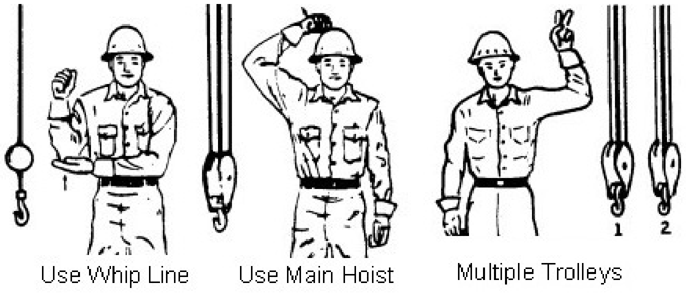
### Radio work practices

Voice directions given to the operator shall be given from the operator's directional perspective. Identify the crane and yourself. Each voice signal shall contain the following elements, given in the following order: function (such as hoist, boom), direction; distance and/or speed; function, stop command. Allow time between commands. Verify the command

Note: The operator shall stop the crane at any time and in any situation judged to be unsafe or when communication is lost. In addition, the operator shall immediately respond to a direction from any person to stop the crane.

## Hook and Trolley Signals

These signals indicate which hook or trolley to use and are used in conjunction with operating signals.



## Auxiliary Hook

When calling for the whip line or auxiliary hoist:

- the elbow is tapped with the opposite hand and
- followed with the appropriate hook movement signal


## Main Hoist

When calling for the main hoist, the signaler:

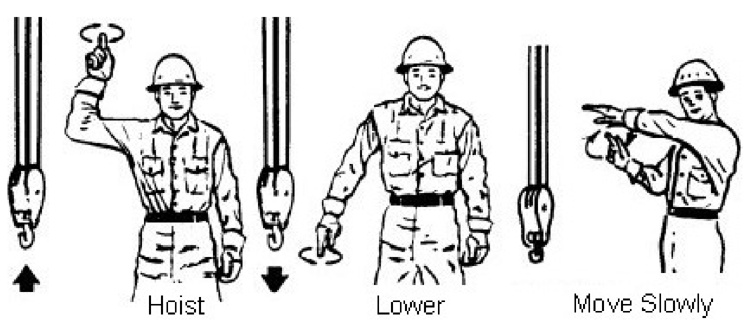
- taps a fist on his or her hard hat and
- follows the appropriate hook movement signal


## Multiple Trolley

When working with a multiple trolley crane, these signals indicate which trolley to use. They are always followed by movement signals.


## Hoist Signals

Hoist and lower signals are the same for all cranes. The distinct circular motion helps the operator see the signal clearly from greater distances and helps distinguish them from other signals.



## Hoist Up


The hoist signal is given with:

- the forearm vertical, the index finger pointing up, and
- the hand moving in small horizontal circles

## Hoist Lower


The lower signal is given with:

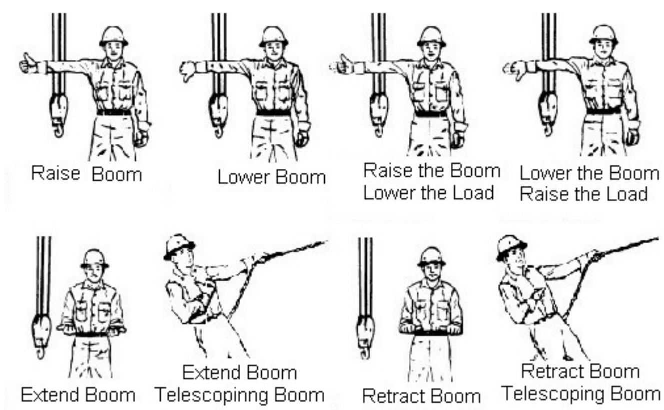
- the arm extended downward,
- the index finger pointed down and
- the hand moving in small horizontal circles

## Hoist up Slowly


A hand held motionless in front of any signal indicates to move slowly. In this clip the rigger is signaling to hoist slowly.

## Boom Signals

Boom signals direct the operator to raise and lower or to extend and retract the boom. Combination boom and hoist signals allow the load to remain at the same height while booming up or down.



Boom Raise (Boom Up)
The signal to raise the boom, or boom up, is given with:

- an extended arm,
- fingers closed and thumb pointing upward


Lower Boom (Boom Down)
The signal to lower the boom, or boom down, is given with:

- an extended arm,
- fingers closed and thumb pointing downward


Raise the Boom – Lower the Load
The signal to raise the boom and lower the load is given with an:

- extended arm,
- thumb pointing upward and
- fingers flexing in and out


Lower the Boom – Raise the Load
The signal to lower the boom and raise the load is given with an:

- extended arm,
- thumb pointing downward and
- fingers flexing in and out

## Boom Extend

The signal to extend the boom is made with:

- both fists in front of the body and
- thumbs pointing outward away from each other


## Boom Extend One Handed

The one handed extend signal is made with:

- one fist in front of the chest and
- the thumb pointing inward with a tapping motion


## Boom Retract

The signal to retract the boom is made with:

- both fists in front of the body and
- thumbs pointing toward each other

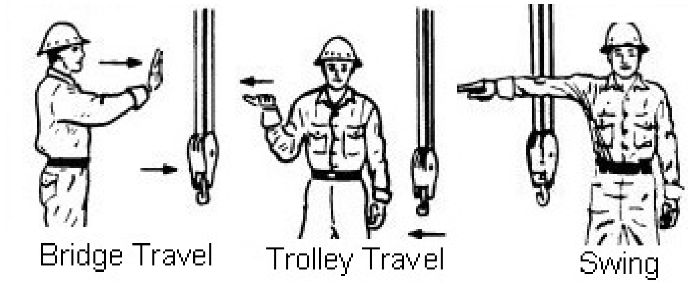

## Boom Retract One Handed

The one handed retract signal is made with:

- one fist in front of the chest, and the
- thumb pointing outward, with a tapping motion

## Directional Signals

Directional signals are used to guide horizontal crane movements such as bridge, trolley and swing.




## Travel Direction


The signal for crane or bridge travel is made with:

- an extended arm,
- hand open with palm facing outward, and
- the hand moving horizontally in the desired direction of travel

## Trolley Direction


The signal for trolley travel is made with:

- a palm up and fingers closed and
- the thumb moving in the desired direction of travel

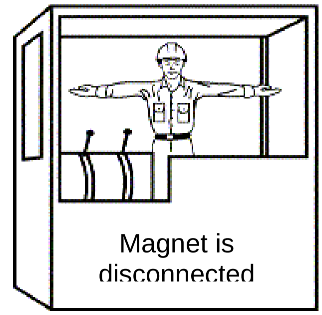
## Rotate (Swing) Direction


The signal for swing or rotate is:

- an extended arm
- the index pointed in the desired direction of rotation

## Magnet Signals

Magnet signals are used to communicate the current status of the magnet - whether it is on or off.



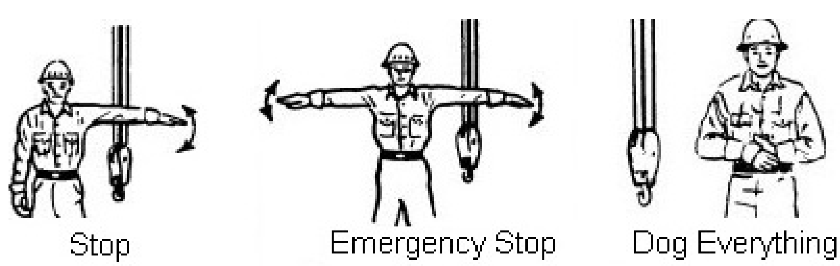

## Magnet Disconnected

The magnet disconnect signal is used to let the person on the ground know that the electricity has been secured and it is safe to disconnect the magnet from the crane. The magnet disconnected signal is given with:

- both extend arms
- palms up and fingers open


## Stop Signals

Stop and emergency stop signals can be given by anyone. When these signals are given, the operator must stop operations as quickly and as safely as possible. The dog everything signal is used when all operations must be secured.



## Stop

The stop signal is:

- an extended arm,
- palm down
- moving back and forth horizontally


## Emergency Stop

The signal for an emergency stop is:

- both arms extended
- with palms down
- moving them back and forth horizontally


## Dog Everything

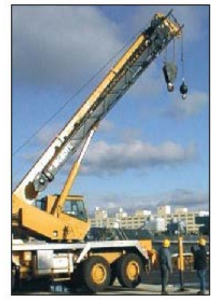
The signal to dog everything is:

- clasped hands in front of the body

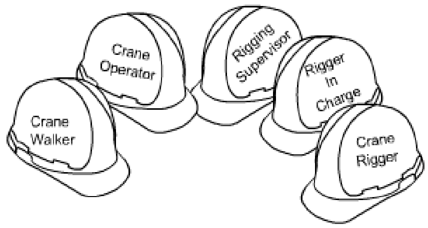
# NOTES

## CRANE TEAM CONCEPT

### CONCEPT



The crane team concept was developed to help ensure that crane operations are executed without injury to personnel, and without damage to property or equipment. To accomplish this goal, the crane team works together to identify and eliminate obstacles to safety.

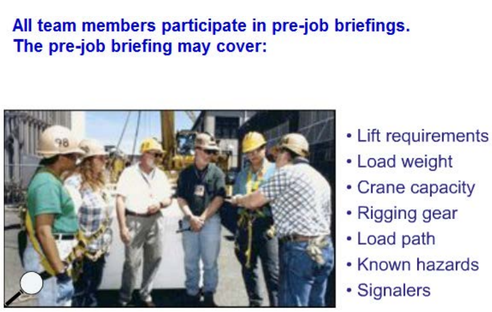



### MEMBERS

The basic crane team consists of the crane operator and the rigger-in-charge. The supervisor may assign other personnel as required. Additional members may include: crane riggers, and a crane walker. The rigging supervisor assigns the crane team members depending on the complexity and scope of work. Either the rigging supervisor or rigger-in-charge may conduct team briefings.

### SHARED RESPONSIBILITIES

While each member of the crane team has individual responsibilities, all team members share some common responsibility, including participation in pre-job briefings, watching for potential problems and making other team members aware of them. All team members are responsible for keeping non-essential personnel away from the crane's operating envelope during lifting evolutions.




### PRE-JOB BRIEFING

A pre-job briefing for complex lifts is conducted by the rigging supervisor, operator supervisor or the working leader and shall be conducted to ensure that all crane team personnel understand the requirements of the lift.

## COMMUNICATIONS

Communications during the lift are just as important as the pre-lift brief. All team members must be made aware of any problems that are discovered.

**Communications between:**
- Members
- Rigger in charge
- Designated signaler

**Communication of:**
- Site conditions
- Personnel locations
- Crane location

*Good communications results in Safe Crane Operations.*

**Team members must stop operations when:**
- Safety is jeopardized
- Personnel board the crane
- The task is not clear

## SAFETY

Stop crane operations before personnel board the crane. Cranes should be positioned to allow safe boarding. Stop work if you're unsure about the assigned task or, if you feel safety is in jeopardy. Have problems resolved before resuming operations.


## RESPONSIBILITIES: CRANE OPERATOR

The crane operator is responsible for performing the pre-use check as well as the safe operation of the crane. The crane operator must have a full understanding of each lift prior to execution and moves only when directed by the signal person.

## ODCL

When performing the pre-use check of the crane, the operator follows and completes the Operator's Daily Checklist, the ODCL.

ODCL Includes:

- walk around check
- machinery check
- operator's cab check
- no load operational check

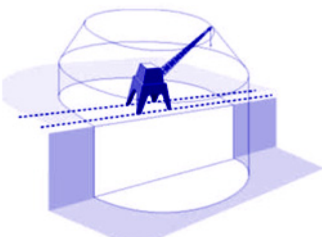
## UNDERSTANDING THE LIFT

Before making a lift, the crane operator must have a full understanding of the lift and how it is to be executed. The operator must know the exact or estimated load weight, the destination, and the capacity of the crane as it is configured.

**Lift variables:**

- Load weight
- Load destination
- Crane capacity

- A vehicle or pedestrian enters the crane envelope
- Communications are lost during a complex or blind lift
- A stop signal is given



## STOPPING OPERATIONS

The crane operator must immediately stop operations when the operating envelope is penetrated, if communications are lost during a blind or complex lift, and anytime a stop signal is given by anyone.

## RESPONSIBILITIES: RIGGER-IN-CHARGE

The rigger-in-charge has overall responsibility for the safety, planning, and control of the lift. The Rigger-In-Charge ensures that each load is rigged properly and the crane envelope is kept clear. He or she also signals the crane operator or designates other personnel to provide signals and coordinates the activities of the crane team members.

**The rigger in charge:**
**- Coordinates the activities of crane team members.**
**- Has overall control of the lift.**

**Plans all aspects of the lift:**

- Determining the load weight
- Determining the load path
- Establishing communications

**Oversees the lift:**

- Ensuring the load is properly rigged
- Keeping the operating envelope clear
- Providing signals to the operator
- Assigning alternate signalers
- Conducting operations in a safe manner

## LIFT PLANNING

The rigger-in-charge plans all aspects of each lift. He or she determines the load weight and center of gravity of each load and then selects the proper rigging. Next, the load path is determined and the method of communication is planned.

Lift planning includes:

- Determining load weight
- Determining the Center of Gravity
- Gear selection
- Defining the load path
- Communications

## RESPONSIBILITIES: CRANE RIGGER

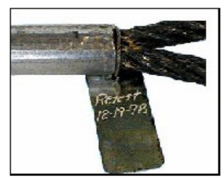
A crane rigger is responsible for carrying out assignments from the rigger-in-charge or the rigging supervisor. These duties include assisting the crane operator with the pre-use check, selection and inspection of rigging gear, safely rigging the loads and keeping the rigger-in-charge informed.

## ASSISTING WITH ODCL

The crane rigger assists the operator in performing the pre-use check of the crane and work area.







## SELECTING & INSPECTING GEAR

The crane rigger selects and inspects crane rigging gear, and establishes proper attachment points as directed by the rigger-in-charge.

## COMMUNICATIONS

A crane rigger keeps the rigger-in-charge informed of questionable or unsafe conditions and changes that may affect the operation.

## RESPONSIBILITIES: CRANE WALKER

Often a crane supervisor will assign a crane walker to the crane team. Like the crane rigger, the crane walker is responsible for carrying out the assignments of the rigger-in-charge and the rigging supervisor.

- Assisting with the pre-use check
- Helping ensure safe crane travel
- Aligning crane rails
- Staying in position to communicate stop signals to operator
- Participating in crane team briefings

### ASSISTING WITH ODCL

A crane walker assists the crane rigger and crane operator in performing the pre-use check of the crane.

### SAFE TRAVEL

The crane walker ensures the crane's travel path is clear by watching for potential obstructions and checking the proper alignment of the crane track switches.


### COMMUNICATIONS

Crane walkers stay near the emergency stop button to communicate the stop signals to the crane operator.

### RESPONSIBILITIES: SUPERVISOR

The supervisor is familiar with NAVFAC P-307 and supports the crane team concept.

**The supervisor:**

- Designates crane team personnel
- Reviews site conditions for complex lifts
- Reviews procedures for operations near electrical lines
- Investigates and reports crane accidents

### SITE CONDITIONS

The supervisor reviews onsite conditions for all complex lifts.

### POWER LINES
The supervisor assesses potential hazards and establishes procedures for safe operations around overhead electrical power lines.

### LIFTS EXCEEDING 80%
Supervises lifts exceeding 80% of capacity (except for lifts using pillar, pillar jib, fixed overhead hoists, or monorail cranes) and lifts exceeding 50% of capacity for mobile cranes mounted on barges. If the lifts are repetitive in nature, the supervisor shall be present during the first evolution of the lift for each rigging crew.

### ACCIDENTS
The supervisor shall inspect suspected accident scenes, notify appropriate authority, and ensure that the accident report is filed.

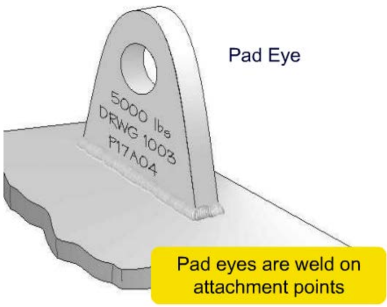
### COMPLEX LIFTS
A supervisor shall review on-site conditions for complex lifts and perform a pre-job briefing with all crane team personnel. A supervisor shall personally oversee all lifts exceeding 80% of the certified capacity of the crane's hoist (except for lifts using pillar, pillar jib, fixed overhead hoists, or monorail cranes) or 50% for mobile cranes mounted on barges. A supervisor shall also supervise multiple hook lifts when the weight exceeds 80% capacity of any hoist, and lifts of ordnance involving the use of tilt fixtures.

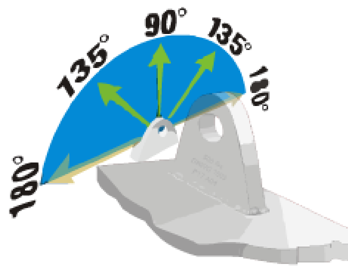
# NOTES

## ATTACHMENT POINTS

### WELD-ON ATTACHMENT POINTS

Attachment points are where the rigging gear is connected to the load. There are many types of attachment points. Weld-on pad eyes are durable attachment-points designed specifically for lifting. Normally, weld-on pad eyes are installed by the manufacturer. When rigging to these attachment points, shackles should always be used.



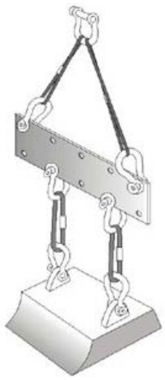




### PAD-EYE CAPACITY

Pad-eye capacities vary depending on design and material. Most pad-eyes, if properly designed and installed, can be used up to 100 percent of rated capacity through a full 180 degree range, provided they are tensioned within the plane of the eye. Side loading is generally limited to 5 degrees or less. However, some published standards allow for side loads of up to 20 degrees out of plane depending on type, size and weld construction. When in doubt, check with your activity's engineering department for specific guidance.

### PAD-EYE VISUAL INSPECTION


Visually inspect pad-eyes, welds and the structure they are welded to before and after each use. Look for: cracks, corrosion, deformation, or other signs of damage or overload. If you have any doubt as to the strength or integrity of the pad-eye or the attached structure, DON'T USE IT. Stop work and contact your supervisor. A properly filled out danger tag should be attached to the pad-eye in question.

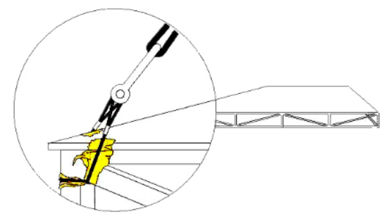


## 'IN-PLANE' LIFTING

There may be times when pad-eye orientation will not allow in-plane loading. Lifting beams can be used to orient the rigging for in-plane loading.

## STRUCTURAL COMPONENTS

If welded pad-eyes are not available, a load's structural component can be used as an attachment point. Be sure the structure can support the load weight and the added tension from sling angle stress.




## USER APPLIED

Sometimes, an attachment point needs to be added to the load. Beam clamps, plate clamps, swivel hoist rings, eye-bolts, or bolt-on pads, may be attached to the load for lifting.


## USER APPLIED OEM REQUIREMENTS

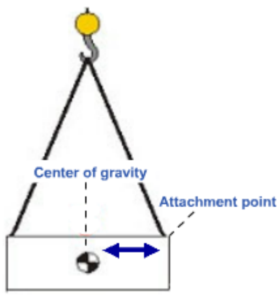
Remember, all rigging gear, including portable user-applied attachment points must be used in accordance with OEM instructions. Be sure to perform a pre-use visual inspection.

### PLACEMENT 1

Choosing the right location for attachment points is very important to maintaining load control. Your choices may be limited due to the weight of the load, how the weight is distributed, the material the load is made of, or how the load is constructed. Is it fragile? Does it have machined surfaces? Consider the size and shape of the load, where the load is going, whether it needs to be rotated or flipped, and the load's center of gravity.

Choices may be limited by:

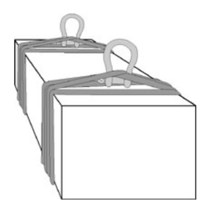
- The weight of the load
- Type of material the load is made of
- How the load is constructed
- The load's size and shape
- Where the load is going
- The load's center of gravity




### PLACEMENT 2

The load's center of gravity should be considered when deciding the placement of attachment points. The farther the attachment points are from the load's center of gravity the more stable the load will be and the less susceptible it is to tipping. The load's center of gravity must remain within the stability triangle formed by the slings otherwise the load can flip or tip over. When choosing attachment points, ask yourself, which method will provide the best control.

### LASHING



What is lashing? The P-307 defines lashing as: "wire rope, synthetic rope, synthetic webbing, or other approved material without permanent end fittings that is used for wrapping and securing around and or through an object to provide a point or points from which to lift." Additionally, lashing may be attached to approved structures to serve as a point from which to rig. Lashing shall not be used to substitute for standard rigging components where the use of such rigging is practical.

### LASHING VS. SLINGS

Why is lashing treated differently than slings? The main reason is that lashing requires the use of knots or clamping devices. Knots and clamping devices can damage the sling material. For this reason slings shall not be knotted or clamped. Because proper lashing methods and techniques are essential for safe weight handling, activities must develop written procedures for the use of lashing when lifting with cranes.

Lashing should not be used when it is practical to use standard rigging equipment, i.e. slings, shackles, etc.

## LASHING REQUIREMENTS

As a minimum, written procedures for lashing loads, for a crane lift, must contain the following work practices:

- Lashing must be inspected before and after each use and damaged portions removed prior to reuse.
- Lashing must be marked with its rated capacity.
- Lashing must be attached tightly to prevent the object being lifted from slipping out.
- Lashing must not be installed so tightly that it crushes the load.
- The object to be lifted must be structurally sound enough to support its own weight when lifted by the lashing.
- The lashing configuration must have at least two parts of lashing supporting the load.
- Knots are not permitted in wire rope lashing.

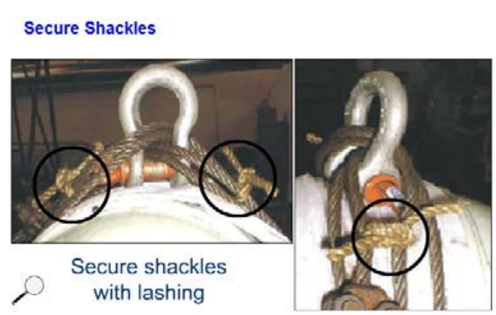
## LASHING WRITTEN PROCEDURES

As a minimum, written procedures for lashing loads must contain the following:

- When using wire rope for lashing, forged steel, wire rope clips shall be used to secure the ends of the wire rope.
- The rated load shall be reduced by 20% or by the D-to-d efficiency factor, whichever is greater.
- When attaching synthetic lashing, properly tied knots or hitches including square knots backed up with half hitches, bowlines, clove hitches etc. may be used to secure synthetic rope and webbing lashing.
- When knots are used the rated load of the lashing shall be reduced by 50%.
- Reductions for knots and wire rope clips are not cumulative with the D-to-d reduction factors. Use the greater reduction.
- The additional stress due to lift angles in the lashing configuration must be taken into consideration to ensure the reduced rated load of the lashing is not exceeded.
- Always use adequate chaffing gear to pad sharp edges.

## SECURE HARDWARE TO LASHING

When using hardware such as rings or shackles with lashing, secure the rigging gear to the lashing to prevent rendering.




## DRIFTING & HARDWARE PLACEMENT/SIZE

If a planned lift will involve drifting or load transfer, the shackle, ring, or other rigging gear, should be positioned "in-line" with the intended direction of travel. Rigging gear attached to the load should be large enough to accommodate two additional shackles for load transfer.

# NOTES

## PRE-PLANNING CRANE LIFTS

### CRANE DANGER ZONES

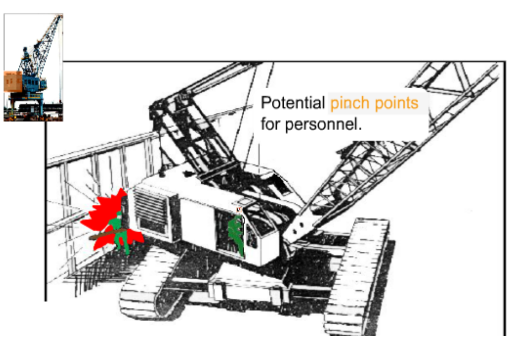
Working safely with cranes involves identifying potential problems before starting the job. Regardless of the crane used, certain components of the crane require constant attention. Crane danger zones include the crane boom, the counterweight, the gantry, and the travel trucks.

### BOOM

Often the crane's boom will be the largest single component on the crane. The potential for collision with buildings and other structures is always present.

### MULTIPLE BOOMS

When two cranes work in the same area, extra precautions must be taken to avoid collisions, especially boom collisions. This potential increases when conducting lifts using two cranes because of the close proximity of the equipment. Careful preparation and good communications are essential.


### COUNTERWEIGHT: ROTATE CLEARANCE

Crane counterweights, especially on mobile cranes, pose a potential hazard to personnel. Serious injury or death can occur if someone gets trapped in the pinch point between the counterweight and an obstacle. Even though portal crane counterweights are not normally a personnel danger zone, they can cause serious damage to anything they come in contact with.

## COUNTERWEIGHT: TRAVEL CLEARANCE

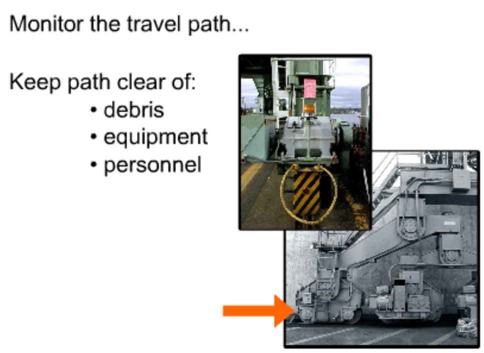
The crane may pass by structures without collision while the boom is parallel to the track. But when traveling with the boom perpendicular to the track the counterweight may overhang the track by ten, twenty, thirty feet or more.

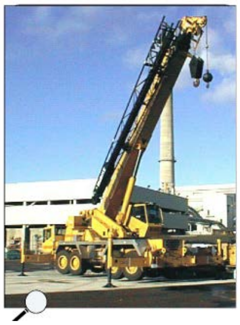

## GANTRY

Gantry clearance should be closely monitored during crane travel. Vehicles attempting to drive under the crane without regard for clearance can jeopardize crane safety.

## TRAVEL PATH: WHEELS/TRUCKS

Items left in the path of travel trucks are usually no match for the power and weight of the crane. Injury to personnel and damage to materials and equipment, including the crane itself, can be avoided if we monitor the crane's travel path and keep it clear at all times.



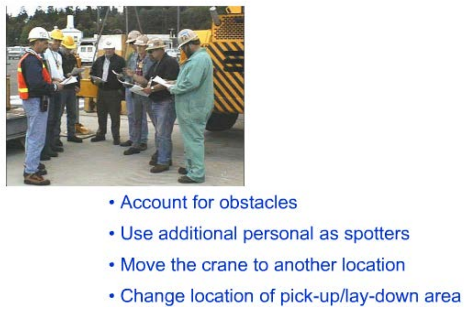



## OBSERVE, MONITOR, MITIGATE

Inspect the crane area work site prior to starting any crane movement. Monitor the area for changing conditions during the work shift. Potential obstacles in the crane's operating envelope should be identified and removed if possible. A plan for working safely around immovable items should be discussed.

## DEVELOP A PLAN

Develop well thought out lift plans to avoid problems. Use additional personnel as crane walkers or spotters. Move the crane to another area or change the pick-up and lay-down areas.




## SPECIAL CONSIDERATIONS

Areas where construction is underway may present some special problems for the crane team. Work site conditions may not be controlled by your facility. Materials and equipment may be left in the area. Portable barriers or fencing may extend into the cranes' travel or swing path. Contractors may not be aware of your crane safety procedures and requirements. Regardless of the circumstances, take the time to ensure crane safety by addressing these issues prior to beginning the operation.

## RESTRICTED AREAS

You may encounter restricted areas that involve ground loading or crane interference, which can limit crane travel or swing maneuvering. Check with your supervisor or safety officer for load restriction information.

**Restricted Travel Areas**

- Interference limiting crane travel or swing
- Underground services
- Ground density

## MOBILE CRANE RADIUS VERIFICATION

For mobile crane lifts that exceed fifty percent of the hook capacity at the maximum planned radius, the radius must either be verified by actual measurement or by operating the crane with an empty hook through the lift evolution and verifying the radii from the radius indicator. For mobile crane lifts that exceed eighty percent of the hook capacity at maximum planned radius, the radius must be verified by measurement when possible. Do not rely on the radius indicator.

**Load Weight - Mobile Cranes**

**For lifts exceeding 50%** hook capacity at maximum planned radius:

- Verify radius by measurement

  *OR*
- Dry run (empty hook) verifying radii from radius indicator

**For Lifts exceeding 80%** hook capacity at maximum planned radius:

- Verify radius by measurement (when possible)

**For lifts exceeding 80%** hook capacity, **do not** rely on the radius indicator!

## COMPLEX LIFTS

Lifts exceeding 80% of the capacity of the hoists are complex lifts. For variable rated cranes, the 80%

**Complex Lifts**

- Moderate to high risk
- Detailed written lift plan
- Detailed rigging sketches

capacity limitation shall be at the maximum anticipated radius. For a mobile crane mounted on a barge, lifts

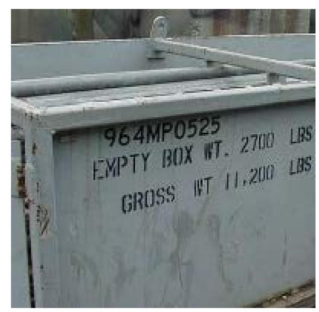
exceeding 50% of the hoist capacity are complex lifts. Lifts exceeding 80% of the capacity of jib cranes, pillar jib cranes, fixed overhead hoists and monorail cranes need not be treated as complex lifts nor do lifts of test weights during maintenance or testing of any type of crane when directed by a qualified load test director.

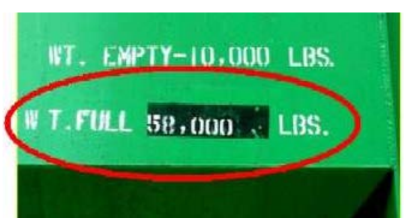

### Equipment Weight Markings

Each activity shall weigh and mark equipment that is lifted by crane, such as man lifts, aerial platform vehicles, forklifts, and mobile cranes with the weight in pounds. OEM marked weights are acceptable.

### Container Weight Markings

Sand hoppers, tubs, and other containers that may carry material must be marked with empty and full weights. Full weight must be established by the OEM or the activity engineering organization. If the weight is not marked, it must be verified using a load indicating device. Always check to see what the contents are. A container designed to hold a relatively light material may be significantly heavier if it is filled up with water.




### Container Contents

Before lifting any type of container, always find out what is inside of it. Is it full? Is it half full? Is it empty? If the container cannot be verified as empty, it must be considered full.

### Container Weight Verification

If the container's weight is not marked, the weight must be verified by weighing. The weighing device, rigging gear, and crane used for the lift must have the capacity to handle the maximum possible load weight.

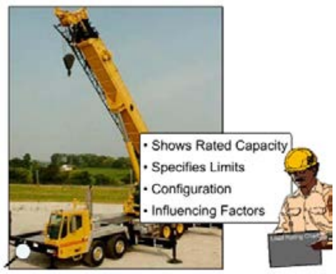
Before lifting a container, verify capacity of the crane, load Indicator, and all rigging gear.

## STOPPING POINTS

Predetermined stop points are a good way to help ensure equipment will not be overloaded. Stop lifting at the anticipated weight of the item. Stop lifting before exceeding the capacity of the weakest link in the rigging gear or exceeding the crane's capacity. Stop points can help prevent overloads. Always keep in mind the 80% complex lift criteria when making these types of lifts.

**Predetermined Stop Points**

- Anticipated weight
  How much strain will you take?
- Weakest link
  Will continuing overload the rigging gear?
- Crane Capacity
  Will crane be overloaded?
  Will 80% complex lift criteria be exceeded?

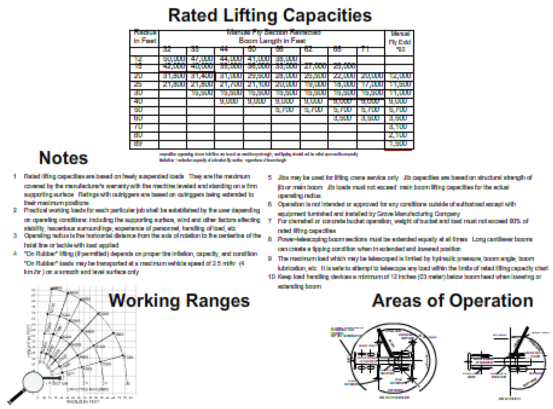



## LOAD CHARTS: GENERAL

A load chart specifies the rated capacity for each permissible configuration, operational limits, and set-up requirements for the various configurations. The load chart identifies principal factors influencing the crane's capacity, such as boom angle, boom length, load radius, deductions from gross capacity, crane configuration, and quadrants of operation.

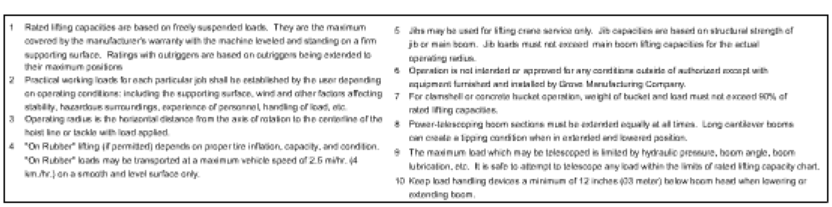
## PARTS OF A LOAD CHART

Most load charts contain a rated capacities chart, a notes section, a range diagram, line pull limitations, and a working area diagram. Some load charts may contain additional information.




## LOAD CHART: NOTES

Before calculating capacity, the operator must read the general notes section. The general notes section includes deductions from the listed capacities, allowable boom lengths, instructions for determining structural and stability limitations, and wire rope and reeving information critical to making a safe lift. The operator will also find set-up requirements, travel configurations, and general crane safety reminders.



1 Rated lifting capacities are based on freely suspended loads. They are the maximum covered by the manufacturer's warranty with the machine leveled and standing on a firm supporting surface. Ratings with outriggers are based on outriggers being extended to their maximum positions.
2 Practical working loads for each particular job shall be established by the user depending on operating conditions: including the supporting surface, wind and other factors affecting stability, hazardous surroundings, experience of personnel, handling of load, etc.
3 Operating radius is the horizontal distance from the axis of rotation to the centerline of the hoist line or tackle with load applied.
4 "On Rubber" lifting (if permitted) depends on proper tire inflation, capacity, and condition. "On Rubber" loads may be transported at a maximum vehicle speed of 2.5 mi/hr. (4 km./hr.) on a smooth and level surface only.
5 Jibs may be used for lifting crane service only. Jib capacities are based on structural strength of jib or main boom. Jib loads must not exceed main boom lifting capacities for the actual operating radius.
6 Operation is not intended or approved for any conditions outside of authorized except with equipment furnished and installed by Grove Manufacturing Company.
7 For clamshell or concrete bucket operation, weight of bucket and load must not exceed 90% of rated lifting capacities.
8 Power-telescoping boom sections must be extended equally at all times. Long cantilever booms can create a tipping condition when in extended and lowered position.
9 The maximum load which may be telescoped is limited by hydraulic pressure, boom angle, boom lubrication, etc. It is safe to attempt to telescope any load within the limits of rated lifting capacity chart.
10 Keep load handling devices a minimum of 12 inches (.03 meter) below boom head when lowering or extending boom.

## LOAD CHART: RATED CAPACITIES

The rated capacity chart is the section of the load chart referenced to determine the crane's gross capacities. Gross capacity depends on the configuration of the crane, the boom length and the load radius. Notice that this chart has a bold line running through the listed capacities. Above the bold line capacities are based on strength of materials; below the line capacities are based on the stability of the crane. Some manufacturers use the bold lines to denote lifts in the tipping range. Some use an asterisk while others use shaded areas.

| Radius in Feet | Manual Fly Section Retracted Boom Length in Feet | | | | | | | | Manual Fly Extd. |
|---|---|---|---|---|---|---|---|---|---|
| | 32 | 33 | 44 | 50 | 56 | 62 | 68 | 71 | *92 |
| 12 | 50,000 | 47,000 | 44,000 | 41,000 | 38,000 | | | | |
| 15 | 42,000 | 40,000 | 39,000 | 36,000 | 33,000 | 27,000 | 25,000 | | |
| 20 | 31,800 | 31,400 | 31,000 | 29,500 | 28,000 | 25,500 | 22,000 | 20,000 | 12,000 |
| 25 | 21,800 | 21,800 | 21,700 | 21,100 | 20,000 | 19,000 | 18,000 | 17,000 | 11,500 |
| 30 | | 15,500 | 15,500 | 15,500 | 15,500 | 15,500 | 15,500 | 15,500 | 11,000 |
| 40 | | | 9,000 | 9,000 | 9,000 | 9,000 | 9,000 | 9,000 | 9,000 |
| 50 | | | | | 5,700 | 5,700 | 5,700 | 5,700 | 5,700 |
| 60 | | | | | | | 3,500 | 3,500 | 3,500 |
| 70 | | | | | | | | | 3,100 |
| 80 | | | | | | | | | 2,100 |
| 89 | | | | | | | | | 1,500 |

Capacities appearing above bold line are based on machinery strength, and tipping should not be relied upon as the capacity limitation.
* Indicates capacity of extended fly section, regardless of boom length.

## LOAD CHART: GROSS CAPACITY

The gross capacity is the value shown on the manufacturer's load chart. Gross capacities are not the values, or load weights, that can be suspended from the crane hook. Gross capacities include the weight of everything mounted on, stowed on, or hung from the boom. How do we know how much weight can be lifted on the hook? Net capacity must be calculated to determine how much load the crane can safely lift.

| RADIUS | BOOM LENGTH 33' | | | BOOM LENGTH 45' | | | BOOM LENGTH 57' | | |
|---|---|---|---|---|---|---|---|---|---|
| | Angle | FRONT | 360° | Angle | FRONT | 360° | Angle | FRONT | 360° |
| 10 | 67 | 80,000 * | 80,000* | 74 | 75,000* | 75,000* | 74 | 59,600* | 59,600* |
| 12 | 63 | 76,100* | 76,100* | 71 | 73,000* | 72,900* | 72 | 55,000* | 55,000* |
| 15 | 57 | 64,200* | 63,200* | 67 | 61,700* | 61,700* | 66 | 46,300* | 45,700* |
| 20 | 46 | 45,800* | 45,300* | 60 | 46,100* | 45,600* | 60 | 35,300* | 35,000* |
| 25 | 31 | 34,700* | 34,400* | 52 | 35,100* | 34,800* | 54 | 28,800* | 27,800* |
| 30 | | | | 43 | 27,800* | 27,600* | 47 | 22,800* | 22,600* |
| 35 | | | | 32 | 22,500* | 22,400* | 40 | 18,900* | 18,700* |
| 40 | | | | 15 | 17,600* | 17,500* | 32 | 15,800* | 14,700* |
| 45 | | | | | | | 20 | 12,700* | 11,700* |

The weight of **everything**:
mounted or stowed on the boom
+ hanging from the boom tip

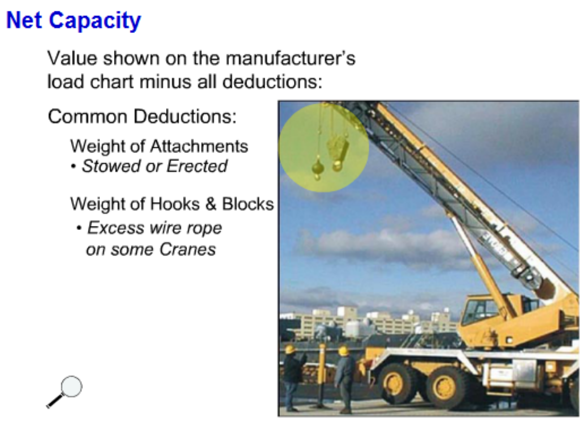
**45,800** **Gross Lifting Capacity**

## LOAD CHART: NET CAPACITY

Net capacity equals the value shown on the load chart, or gross capacity, minus all required deductions.

"Net Capacity" is
gross capacity less all deductions

| RADIUS | BOOM LENGTH | | | BOOM LENGTH | | | BOOM LENGTH 57' | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | Angle | FRONT | 360° |
| 10 | 67 | 80,000 * | 80,000* | 74 | 75,000* | 75,000* | 74 | 59,600* | 59,600* |
| 12 | 63 | 76,100* | 76,100* | 71 | 73,000* | 72,900* | 72 | 55,000* | 55,000* |
| 15 | 57 | 64,200* | 63,200* | 67 | 61,700* | 61,700* | 66 | 46,300* | 45,700* |
| 20 | 46 | 45,800* | 45,300* | 60 | 46,100* | 45,600* | 60 | 35,300* | 35,000* |
| 25 | 31 | 34,700* | 34,400* | 52 | 35,100* | 34,800* | 54 | 28,800* | 27,800* |
| 30 | | | | 43 | 27,800* | 27,600* | 47 | 22,800* | 22,600* |
| 35 | | | | 32 | 22,500* | 22,400* | 40 | 18,900* | 18,700* |
| 40 | | | | 15 | 17,600* | 17,500* | 32 | 15,800* | 14,700* |
| 45 | | | | | | | 20 | 12,700* | 11,700* |

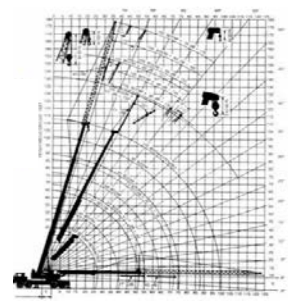


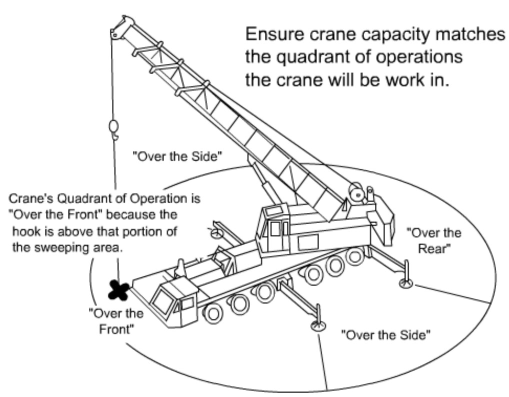

## NET CAPACITY DEDUCTIONS

To calculate net capacity, deductions such as the weight of the attachments, extensions, swing away jibs, and auxiliary boom nose sections must be calculated. Attachments are listed in stowed or erected positions. The effective weight of these attachments will be listed in the load chart notes section.

## LOAD CHART: RANGE DIAGRAM

Range diagrams can be used in the pre-planning stage of a lift to help the rigger identify the crane configuration, the usable hook height, the boom angle, and the radius. This information will help the operator determine if the crane will reach the required distance. When lifting loads to areas such as building tops, jib length and available offset can let the rigger know if the boom will clear the structure when the hook is over the object to be lifted or landed.






## LOAD CHART: QUADRANTS OF OPERATION

Another section of the load chart is the Working Area Diagram or Quadrants of Operation. On some cranes the capacity changes as it rotates from one quadrant of operation to another. This diagram shows the crane's working quadrants.

## Overload Consequences

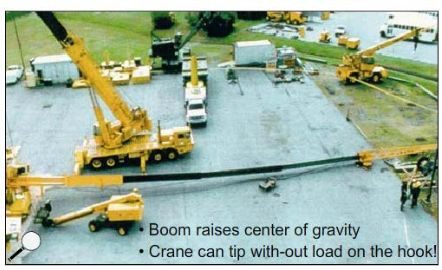
Why is understanding and using a load chart critical to crane safety? Exceeding the crane's rated capacity can result in one of two consequences, loss of stability or structural failure.

## Loss of Stability: General

Loss of stability occurs when the tipping force of the load overcomes the counteracting or stabilizing force of the crane. Recovery is difficult because as the crane begins to tip - the load radius increases - as the load radius increases - the capacity decreases. Once tipping begins, it's unlikely the operator can recover. Therefore, its critical for crane operators and riggers to know the working capacity of each crane they are assigned.

## Loss of Stability: Hydraulic Boom Crane

Tipping on telescopic boom cranes can happen more rapidly because of the weight of the boom on these types of cranes. The heavy boom raises the center of gravity of the crane, allowing it to move forward more rapidly. In fact, many telescopic boom cranes will tip with no load on the hook, if the boom angle is too low and the boom is extended too far.




## Loss of Stability: "Seat-of-the-Pants"

The crane operator must never rely on signs of actual tipping to determine whether the load is within capacity. This is called operating by the "seat-of-the-pants" and can result in catastrophic failure.

## STRUCTURAL FAILURE

Structural failure isn't limited to total failure as pictured here. Structural failure can occur when rated capacity is exceeded and may occur before any signs of tipping. It can include hidden damage that may contribute to a later catastrophic failure. Loss of stability and structural failure from overloading are always avoidable when you remain within the crane's capacity.

## PRE-JOB BRIEFING: WHAT

Pre-job briefings are a decision making tool used by the crane team to anticipate hazards, minimize risks associated with the job, and reduce the potential for accidents.

- Decision making tool
  - anticipate hazards
  - minimize risks
  - reduce accident potential
- Ensures all team members understand:
  - specific assigned responsibilities
  - all rules and procedures for making the lift
  - potential dangers and how to avoid them

## PRE-JOB BRIEFING: WHEN

Pre-job briefings are also a communication tool to ensure that all team members understand assigned responsibilities, procedures for making the lift, and potential dangers associated with each lift and how they can be avoided.

- At the beginning of each shift
- Prior to all complex lifts
- Prior to operations at new locations
- When new personnel are added to Crane Team

- Rules, policies, or procedures
- Personnel qualifications
- Communication methods
- Crane and gear capacities
- Crane peculiarities
- Crane inspection results


## PRE-JOB BRIEFING: TOPICS 1

Topics discussed at a pre-lift briefing should include activity safety policies, the lift procedure, assignment of duties, communication methods, and peculiarities of the crane.

### PRE-JOB BRIEFING: TOPICS 2

A pre-lift briefing should include discussion of the load landing area. Is it easily accessible and of sufficient capacity to support load? Individual responsibilities should also be discussed. Who is responsible to do what, and when? Briefings should always include hazards in the crane work area including crane clearances, load travel paths, and load weight.


### PRE-JOB BRIEFING: TOPICS 3

Has the load's center of gravity been identified? Discuss load controlling methods such as chain hoists, hold backs, and tag lines as appropriate. Is a load indicating device required? If so, who will be assigned to monitor it? Are pre-determined stop points needed? A positive means of transferring load control from one signaler to another should also be discussed.

### PRE-JOB BRIEFING: TOPICS 4

Consider ground conditions. Discuss outrigger cribbing as appropriate. If a portal crane is being used, have tracks and switches been checked for proper operation, condition, and position? You may need to discuss traffic control and weather concerns. These are only some of the topics that you may need to address during the briefing.

# NOTES

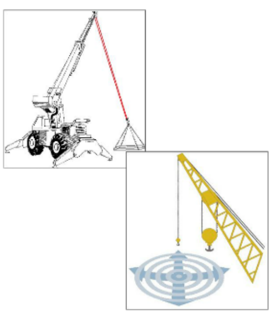
## Executing Crane Lifts

### Moving Loads Near People

Never suspend or move loads over personnel. Look for an alternate load path. If an alternate path is not practical, don't risk personnel safety for the sake of job speed. Evacuate personnel from the load path area before allowing the load to pass over work areas.

### Riding Loads

Personnel are not permitted to ride loads being moved by cranes. If rigging or loading orientation requires adjusting use another type of access whenever possible. Choose a personnel lift, scaffolding or ladders. Do not use the load as a means of transportation!

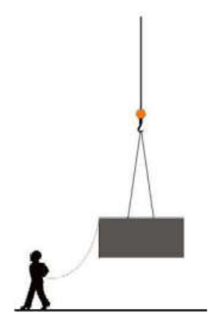


### Side and End Pulls

Crane booms and sheaves are not designed for side pulls or inward or outward leading loads. In some cases, even small out of plumb pulls can cause severe wire rope or sheave damage. Be sure the hook is centered over the load prior to attaching the rigging to the load.

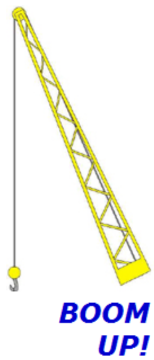
### Load Height

When moving a load from one point to another, the load should be as low to the ground as possible. If the load must be carried higher to clear obstacles, tag lines of sufficient length should be used to maintain load control.



## WATERBORNE LIFTS

When lifting loads from water, you may encounter suction from the sediment at the bottom. Flat bottom loads may experience a suction effect just prior to clearing the water. Loads with pockets, voids, or tanks may hold water that can increase anticipated load weight when the load is lifted above the water. Always use a load-indicating device. Without a load-indicating device, it would be difficult to accurately calculate the increased load on the crane and rigging gear. Tide changes and wave action can cause overloads, shock loads and loss of control. A plan should be developed to account for these.

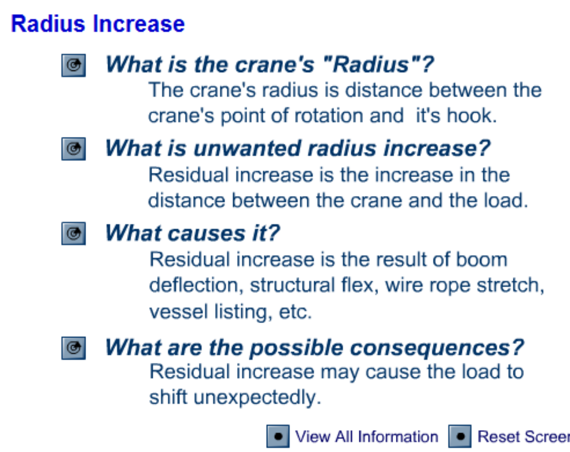



## CRANE STABILITY

Avoid lower than necessary boom angles. As always, be sure to talk with the crane operator whenever crane stability issues come up.

## RADIUS INCREASE

Residual radius increase is an unwanted increase in the crane's operating radius when a sufficient load is applied to the hook. Several factors can cause it including boom deflection, flexing in the crane's structure, wire rope stretch, and for floating cranes - vessel listing. It can cause the load to shift or lunge as it lifts. If you're not prepared, personnel or nearby equipment could be jeopardized!



## RADIUS INCREASE POTENTIAL DANGERS

If we do not compensate for the movement, personnel injury and/or material damage can occur!

## CONTROLLING RADIUS INCREASE

So how do we control this movement?

First, talk to the crane operator whenever you think a lift might be susceptible to load radius increase. Communicate to the crane operator to place the rigging over the load's center of gravity using a boom angle which will minimize radius increase. Connect the rigging gear to the load and signal the operator to hoist slowly to remove slack. When the slack in the lifting gear has been removed, signal the operator to boom up slowly while you watch that the hoist wires remain plumb. It may be necessary for the crane operator to raise the hoist and boom alternately in small increments to ensure the hook stays centered until the load is completely suspended.

## FLOATING CRANE RADIUS INCREASE CONCERNS

Floating cranes have a unique characteristic that can increase the radius significantly. In addition to boom deflection, floating cranes can list, as their barge leans deeper into the water in the direction of lift. This listing movement can adversely affect load control. Allow additional space around the load as a buffer zone.

**Floating Crane Radius Increase**

- Listing occurs in addition to:
    - boom deflection,
    - crane flex, etc.
- Radius increase can be dramatic
- Boom up method - most effective
- Allow additional space for buffer zone
- Extra safety precaution to help prevent
    - injury or
    - damage


## LIFTING GUIDELINES

As soon as the load is completely suspended, signal the operator to stop hoisting. At this time, the crane operator can check the hoist brakes. If a load indicating device is being used, the load weight can be verified if necessary. It's a good idea to record the weight for future reference.

## INSPECT AND ADJUST RIGGING

Maybe a shackle has turned or a sling is pinched or hung-up on an obstruction. Now is a good time to re-check the load for any loose material that could fall off during movement. This is the last chance you'll get to correct any of these problems

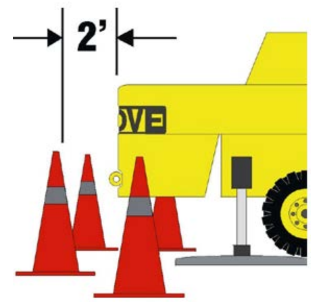
**Inspect and Adjust Rigging**

1. Load level and well balanced
2. Gear "set" properly
3. All sling legs loaded
4. Loose material
5. Take time to correct
6. Don't rush into lifting loads!

before sending the load off. Take the time to make these corrections. Don’t rush and don’t send an unsafe load aloft.

## ROTATE CLEARANCE ZONE: 2’ RULE

To help ensure the safety of personnel in the crane work area, remember the two-foot rule.




NAVFAC P-307 states:

"No part of a crane's rotating structure shall become closer than two feet from an obstruction that could trap a worker."


## ROTATE CLEARANCE ZONE: COUNTERWEIGHTS

One critical area for personnel safety is the swing radius of the counterweight on mobile cranes. Accessible areas within the swing radius of the rotating structure of a crane must be barricaded to prevent personnel from being struck or crushed by the crane. This can be accomplished a number of ways including barricades, cones, and warning tape.

## MOBILE CRANE TRAVEL WITH LOAD: OEM

Prior to traveling a mobile crane with a load attached, be sure to ask the crane operator if traveling with a load is permitted. Your activity may have specific rules regarding traveling mobile cranes with loads. Check with your supervisor.

## MOBILE CRANE TRAVEL WITH LOAD: SET-UP

When traveling with a load, when practical, the outriggers should be kept extended and pads just above the ground. Keep the boom parallel with the direction of travel. Always keep loads as close to the ground as safely possible. Minimize radius to maximize stability.

**Traveling with Loads**

- Outriggers 3 to 4 inches from ground
- Boom in direction of travel
- Keep loads close to ground
- Minimize radius

## LANDING LOADS: CONGESTION

Avoid landing loads in congested areas. Whenever possible, land the load in an uncluttered area visible to both you and the operator.

## LANDING LOADS: EMERGENCY ACCESS

It's extremely important to leave emergency access routes open. Avoid landing loads in fire lanes and emergency access routes.


## LANDING LOADS: TRAFFIC

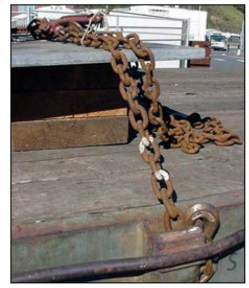
Remember - do not lift loads over personnel. Avoid landing loads in front of access ladders, platforms and doorways. Secure the area before attempting to land the load.

## LANDING LOADS: GROUND LOADING

Be sure the landing surface can support the weight of the load.

## LANDING LOADS: BLOCKING, CRIBBING

Use adequate blocking or support material to prevent damage to the load and the landing surface. Be sure that the load is stable before unhooking it from the crane.



## SECURING LOADS

Tie down materials must be strong enough to control unwanted load movement. Inspect tie down points for defects, such as cracks, broken welds, and distortion.

# NOTES

## SAFE OPERATIONS 1

### UNDERSTANDING THE CRANE

Most crane accidents can be avoided by consistently practicing basic safety procedures. Team members are often to blame for crane accidents, due to inattention, poor judgment, overconfidence, or haste. Understanding the crane is the operator's first responsibility. Crane operators at naval activities must often operate a variety of cranes. They must be familiar with each type of crane they are qualified to operate.



### OPERATIONS MANUAL

Operators must read and follow the manufacturer's requirements, written procedures, safety instructions, and precautions.

### POSTED INFORMATION

The operator must heed posted warnings and instructions on the crane such as hand signal placards, controller function labels, and warning labels. Certification information should be posted in plain sight.


- Standard hand signal chart
- Controller function labels
- Warning tags and labels
- Certification information
  - Crane ID number
  - Certification expiration date
  - Rated capacity of crane
  - Rated capacity of each hook

### PRE-USE CHECK

To make sure the crane and work area are safe, the operator performs a mandatory daily crane inspection using the Operator's Daily Checklist.

### OPERATOR AWARENESS

When operating a crane, the operator must be aware of everything in the operating envelope including hazards, obstructions, and personnel. At the same time the operator must be aware of the sound, feel, and behavior of the crane.

## Stopping Operations for Safety

Whenever an unsafe condition exists, operators must immediately stop operation and the condition must be resolved before continuing. If you cannot resolve a safety issue with the team members, contact the supervisor for assistance. Remember, operators have the authority and responsibility to stop and refuse to operate the crane until safety is assured.

## Lifts Near People

Loads must never be moved or suspended over personnel. Choose an alternate load path or evacuate personnel from the area.

## Riding Loads Prohibited

Personnel must never ride loads. Use only approved personnel-lifting devices if personnel must be lifted.

## Overhead Power Lines

Whenever working near overhead power transmission lines, have the power de-energized and visibly grounded. When the power cannot be de-energized, the minimum required clearances described in figure 10-3 of NAVAC P-307 must be maintained. If any part of the crane or load could approach the distances noted in figure 10-3 of NAVAC P-307, a designated signaler shall be assigned. In addition, a supervisor shall visit the site, assess potential hazards, and establish procedures to safely complete the operation. Follow the requirements of NAVFAC P-307 paragraphs 10.11.1 through 10.11.1.6 for crane operations near or below overhead electrical transmission lines, operation near communication towers, and travelling below power lines.

**Power**

- de-energized and
- grounded

**If the lines can't be de-energized**

Maintain limit of approach

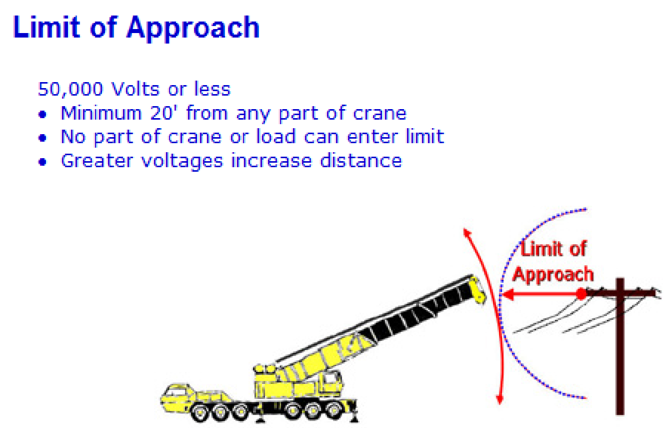
- Allow for wind sway
- Use a designated signaler

Follow the requirements of NAVFAC P-307 paragraphs 10.11.1 through 10.11.1.6 for crane operation near or below overhead electrical transmission lines, operation near communication towers, and travelling below power lines.

Danger Zone NAVFAC P-307

Required clearance for normal voltage in operation near high voltage power lines and operation in transit with no load and boom or mast lowered.

| NORMAL VOLTAGE, KV (PHASE TO PHASE) | MINIMUM REQUIRED CLEARANCE, FT (M) |
|---|---|
| **Operation Near High Voltage Power Lines** | |
| 0 to 50 | 20 ( 6.10) |
| Over 50 to 200 | 20 ( 6.10) |
| Over 200 to 350 | 20 ( 6.10) |
| Over 350 to 500 | 50 (15.24) |
| Over 500 to 750 | 50 (15.24) |
| Over 750 to 1000 | 50 (15.24) |
| **Operation in Transit with No Load and Boom or Mast Lowered** | |
| 0 to 0.75 | 4 (1.22) |
| Over 0.75 to 50 | 6 (1.83) |
| Over 50 to 345 | 10 (3.05) |
| Over 345 to 750 | 16 (4.87) |
| Over 750 to 1000 | 20 (6.10) |




## LIMIT OF APPROACH

When operating in the vicinity of overhead transmission lines, the best crane set up is one in which no part of the crane or load can enter the clearance limit. Even boom failure should not allow the crane, load line, or load to enter the limit.

## OPERATING PRACTICES

The crane operator must operate the crane in a safe manner, moving loads slowly and smoothly. Avoid rapid starts and sudden stops to help reduce load swing. Anticipate stopping points, and slow down before bringing loads to a stop. Never leave a suspended load unattended.

## LIFTING THE LOAD

When lifting loads, position the freely suspended hook directly over the load for vertical lifting. This prevents side loads and prevents load shifting at lift-off. Take the slack out of rigging gradually and watch for hook movement that indicates the need to reposition the crane before lifting. Stop when the load lifts a few inches off the ground and check the hoist brake. Accelerate smoothly to reduce dynamic loading.

Lifting procedure:

- Attach tag lines for control
- Take up slack gradually
- Lift slowly
- Stop, check hoist brake
- Accelerate smoothly

## LANDING THE LOAD

When lowering loads, be sure the surface that you plan to land on will support the load. Slow the load down as you approach the landing surface. To land heavy loads softly, stop the load a few inches off the ground and allow the load to settle before touching down.

## SECURING THE CRANE

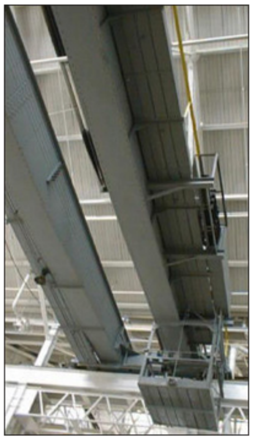
When securing cranes remove gear from the hook, place all controls in the neutral position and engage all brakes and locks. Stow hooks near, but not in, the limit switches. For cranes located outdoors, secure the crane against wind movement and chock the wheels as necessary.

- Remove gear from hook
- Raise hooks below limit
- Place controls in neutral
- Set all brake and locks
- Secure power
- Secure the crane

## TRAVELING THE CRANE

When traveling cranes with loads, stow unused hooks, follow OEM requirements and keep loads close to the ground while avoiding obstructions. Use slow speeds for better load control. Be aware of travel restrictions, and other cranes working in the area. Remember to check clearances and watch for obstructions.

**When moving cranes with loads:**



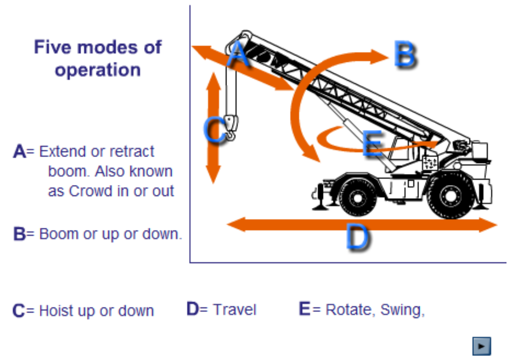
- Follow OEM requirements
- Keep load just high enough to clear obstacles
- Use slow speeds
- Stow unused hooks
- Look for other cranes nearby
- Be aware of any travel restrictions
- Check clearances and obstructions

# NOTES

## SAFE OPERATIONS 2

### MOBILE CRANES: TERMINOLOGY

There are five common modes of operation for a typical mobile crane: booming up or down, rotating, traveling, hoisting up or down, and extending and retracting the boom. Raising or lowering the boom is also known as booming or luffing. Rotate sometimes called swing or slew, causes the upper-works of the crane to revolve on the carrier. Travel mode allows the operator to move the entire crane on wheels, tires or crawler tracks. Hoist mode is used to raise and lower the hooks. For extendible boom cranes, like the one shown, the extend or retract boom mode sometimes referred to as crowding is used to lengthen or shorten the boom.

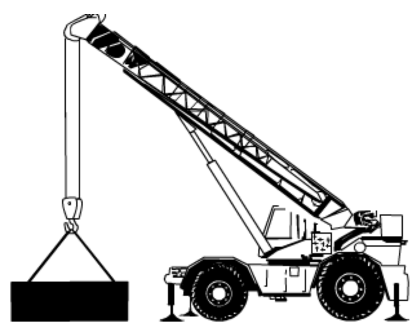



### MOBILE CRANES: HOOK/BLOCK: WEAK LINK

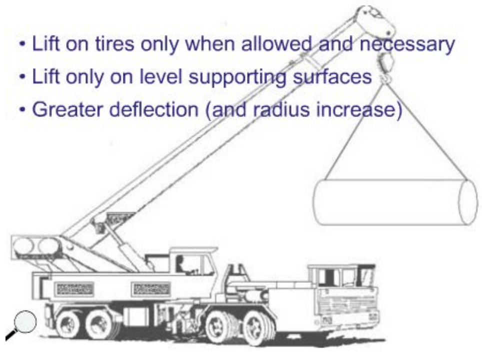
When traveling a truck, cruiser, or crawler crane to and from job sites, secure the hook and block to the carrier frame to prevent them from swinging into the boom. To secure the hook block to the crane, use a weak link such as nylon rope. The breaking strength of the weak link shall be less than the rated capacity of the hook block's wire rope as reeved. When securing the hook blocks for highway travel add a back-up tie-back to prevent free swinging in the event of weak link failure. Tension the hoist just enough to take up the slack. Do not over tighten. Check for adequate clearances between hook blocks and boom tip. Follow all the OEM instructions for traveling the crane. You may need to disengage hydraulic pumps, remove optional counterweights, or even disassemble the boom.

### MOBILE CRANES: OPERATING

When lifting and landing heavy loads with mobile cranes adjust the boom position as necessary to compensate for deflection. The signal person should assist in keeping the boom tip directly over the load. Use the shortest boom length practical for maximum stability and strength. Use power lowering for positive load control.



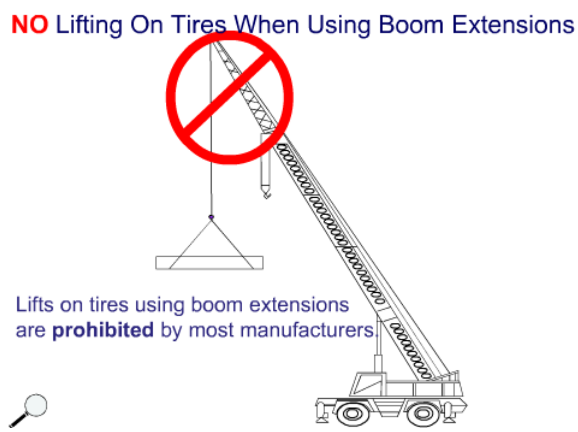
## ON-RUBBER (ON-TIRE) LIFTS




Lift on rubber only when necessary and allowed. Cranes are much less stable on rubber than when on outriggers. Lift only on level surfaces. You must keep the crane level when operating on outriggers or on tires. Remember, greater deflection and radius increase can be expected when making lifts on tires.

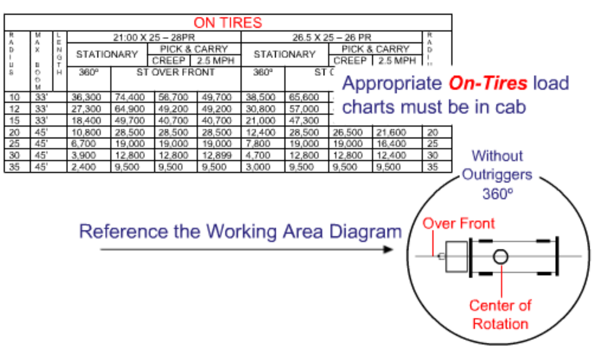
## TIRE CONDITION/INFLATION

Check all tires for condition and inflation to OEM specifications. Axle lockouts must be tested according to OEM instructions to ensure proper operation.




## ON-RUBBER LIFTS: BOOM CAUTION

Check the crane's manual and load chart information before using a jib or extension. Lifting from jibs or boom extensions while on rubber is prohibited by most manufacturers.



ON TIRES

| RADIUS | MAX BOOM LENGTH | 21:00 X 25 – 28PR STATIONARY 360° | 21:00 X 25 – 28PR STATIONARY ST OVER FRONT | 21:00 X 25 – 28PR PICK & CARRY CREEP | 21:00 X 25 – 28PR PICK & CARRY 2.5 MPH | 26.5 X 25 – 26 PR STATIONARY 360° | 26.5 X 25 – 26 PR STATIONARY ST OVER FRONT | 26.5 X 25 – 26 PR PICK & CARRY CREEP | 26.5 X 25 – 26 PR PICK & CARRY 2.5 MPH | RADIUS |
|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 33' | 36,300 | 74,400 | 56,700 | 49,700 | 38,500 | 65,600 | | | |
| 12 | 33' | 27,300 | 64,900 | 49,200 | 49,200 | 30,800 | 57,000 | | | |
| 15 | 33' | 18,400 | 49,700 | 40,700 | 40,700 | 21,000 | 47,300 | | | |
| 20 | 45' | 10,800 | 28,500 | 28,500 | 28,500 | 12,400 | 28,500 | 26,500 | 21,600 | 20 |
| 25 | 45' | 6,700 | 19,000 | 19,000 | 19,000 | 7,800 | 19,000 | 19,000 | 16,400 | 25 |
| 30 | 45' | 3,900 | 12,800 | 12,800 | 12,899 | 4,700 | 12,800 | 12,800 | 12,400 | 30 |
| 35 | 45' | 2,400 | 9,500 | 9,500 | 9,500 | 3,000 | 9,500 | 9,500 | 9,500 | 35 |

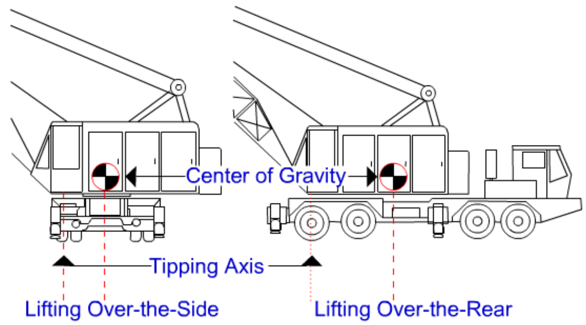


## ON-RUBBER (ON-TIRE) LOAD CHART

When lifting on rubber is permitted at your activity, you must use the appropriate on-rubber load charts. This chart shows gross capacities when working on tires. The OEM may provide on rubber charts for stationary 360 degrees, locked over-the-front, defined arc over-the-front and pick & carry. Check the working area diagram before lifting on tires.

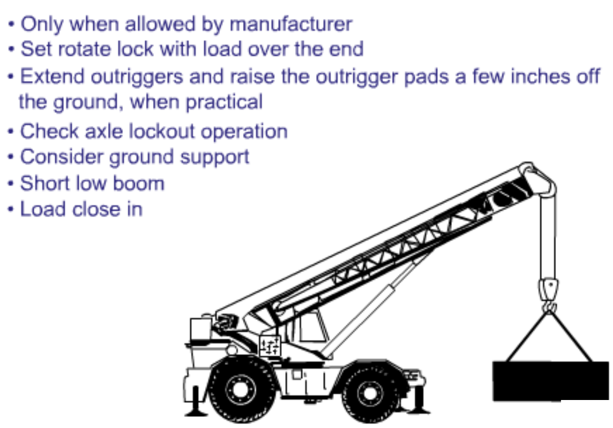
## Center of Gravity

It is important for operators to understand how the center of gravity affects the capacity of the crane when moving from one quadrant to another. The illustration shows a crane on-rubber positioned for lifting over the side and over the rear. The symbol on each crane represents the center of gravity of the entire crane including the carrier. The tipping axis for the crane in each position is the centerline of the outer tires. A crane becomes less stable with the same load applied, whenever the center of gravity of the crane moves closer to the tipping axis. This is why most mobile cranes have a higher over-the-rear capacity than over-the-side.



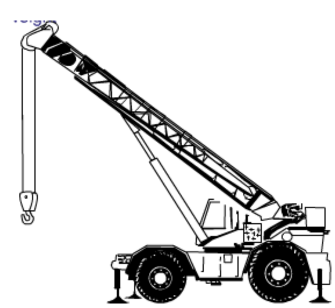

## Mobile Crane: Travel with Load

Travel with suspended loads only when permitted by the OEM and the local activity. Cranes must have appropriate Pick and Carry Load Charts in the operator's cab. Set the rotate lock and travel with the load directly over the end in line with the carrier as required by the OEM. Generally this means carrying over the front with RT cranes and over the rear with truck cranes. Rotate brakes are normally used for holding operating position when the crane is not in line with the crane carrier. When practical and as permitted by the OEM, extend the outriggers and keep the outrigger pads a few inches off the ground. Always check that the automatic or manual axle lock-outs, when equipped are released. Be sure the ground which the crane will travel over can support the machine.




## Operating Extendable Boom Cranes

Lower the hoist block when extending the boom to prevent the block from raising into the limit as the boom is extended. This could result in two-blocking and break the hoist wire rope, dropping the load. Remember that anti two-block devices are operational aids that can fail and must not be relied upon to stop the movement of the hoist. Extend counterweights as required on cranes so equipped. On hydraulic truck cranes, set the front stabilizer float when equipped. Check the operator's manual and load chart notes for instructions on setting the stabilizer float. In many cases, it must be set regardless of the quadrants of operation.



## SECURING EXTENDABLE BOOM CRANES

When securing a truck crane with a hydraulic boom retract the boom fully and place it in the cradle. For rough terrain cranes place the boom in a nearly horizontal position. Requirements for mobile extendible boom cranes may vary from manufacturer to manufacturer. Always consult OEM instructions for securing requirements for each crane.

## OPERATING LATTICE BOOM CRANES

When operating mobile lattice-boom crane lower the hoist blocks to allow boom tip clearance before lowering the boom. Lowering a fixed boom with the load block close to the boom-tip sheaves may result in two-blocking. On many lattice-boom truck cranes, you must also set the front float when equipped for on-outrigger operation. For friction machines, set hoist-drum pawls, when the hoist is not in use. When the crane is equipped with automatic hoist-drum pawls, they should be checked regularly.

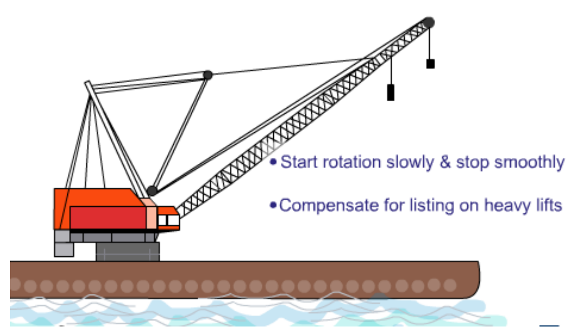


## SECURING LATTICE BOOM CRANES

When securing lattice-boom cranes place the boom at approximately 45 degree, engage hoist drum and boom pawls. Lock down all foot brakes and then disengage the master clutch. Shut down the engine and secure the crane.

## OPERATING FLOATING CRANES

When swinging or rotating floating cranes you must start slowly and stop smoothly. Abrupt starts and stops cause barge rotation putting unnecessary strain on mooring lines. To compensate for the list of the floating crane when lifting heavy loads from the pier, position the hook directly over the load, take a strain on the rigging and then boom up.

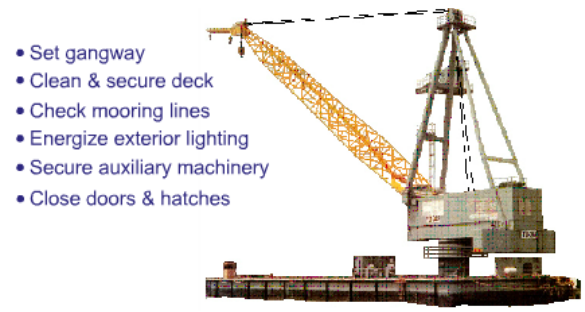


## SECURING FLOATING CRANES

When securing floating cranes, follow OEM and local instructions and set the boom at the recommended angle or so the hooks are over the deck anchor point.  Secure the hooks to the barge using tie-down pendants with a weak link.

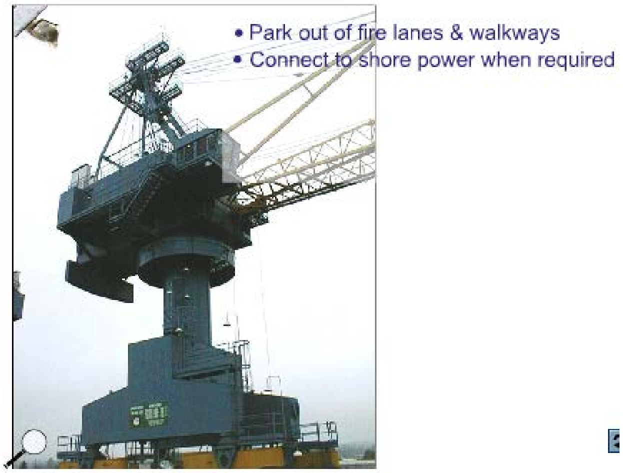
## SECURING FLOATING CRANE BARGE

Secure the floating crane barge as required.  Set the gangway when the crane is moored pier-side.  Clean and secure the deck. Store or secure loose cargo.  Stow unused rigging gear, mooring lines, & ropes.  Check mooring line tension to allow for tidal changes.  At high tide, ensure that lines are slack enough to avoid over-stressing or parting as the tide recedes.  At low tide, snug up mooring lines to minimize barge movement as the tide rises and lines slacken. Energize exterior lighting such as anchor lights and aircraft warning lights as required.  Secure personnel access areas, ladders, auxiliary machinery and close all watertight doors and hatches.




## OPERATING PORTAL CRANES

Travel with caution, especially in congested work areas and when approaching curves, intersections, building entrances, and access to ladders leading into dry docks.  It is a good practice to stop before crossing rail switches to verify correct alignment.  When possible, the operator should position the boom in the direction of travel.  If the crane rigger gives a signal to travel back and disappears from sight, the crane operator must stop traveling until communication is re-established. Clearance lines painted along crane tracks are a guide to keep all materials and vehicles away from crane travel trucks.  Operators shall stop crane travel when materials or vehicles are inside crane clearance lines, until they are moved.

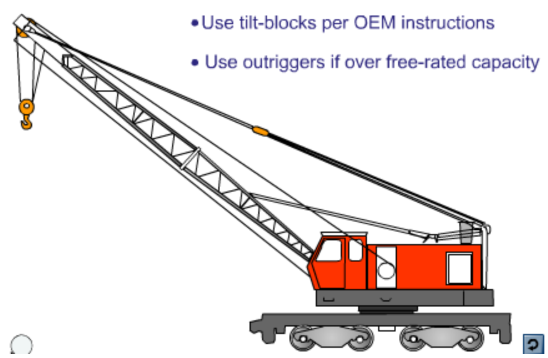



## SECURING PORTAL CRANES

When securing portal cranes, follow OEM recommendations. Park away from fire-lanes, gangways, and pedestrian walkways. When required connect to shore using the proper electrical safety procedures.

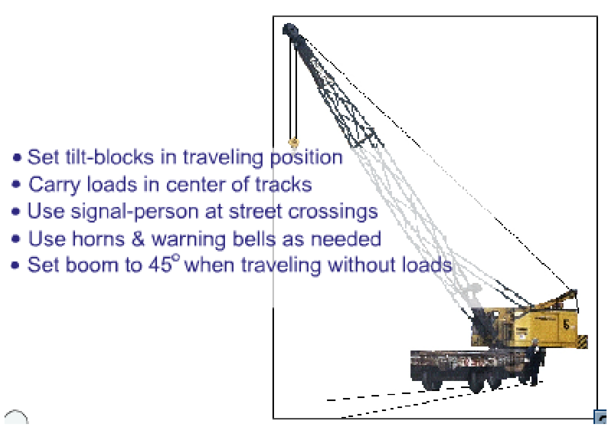
## OPERATING LOCOMOTIVE CRANES

When operating a locomotive crane, use tilt-blocks or bed-stabilizing wedges according to OEM instructions to provide over-the-side stability for heavy lifts. Use outriggers when making lifts exceeding the free-rated capacity of locomotive cranes.



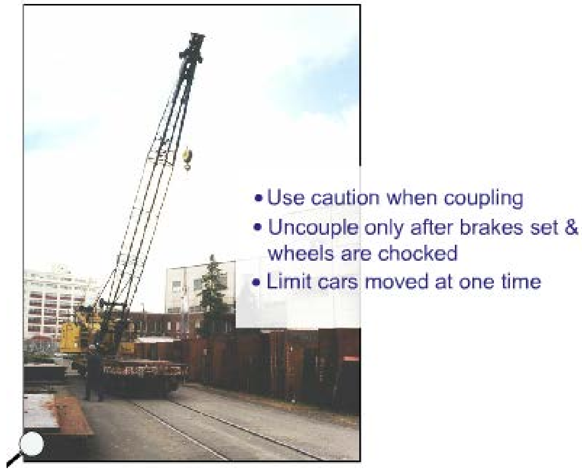

## TRAVELING LOCOMOTIVE CRANES

Disengage tilt-blocks or bed-wedges when traveling and lifting over the side at the same time. Failure to do so may result in derailing the crane because of the decreased ability for the axle assemblies to pivot on the carrier when rounding corners. When traveling around corners, carry loads in the center of the tracks. When this is not possible, carry the load or counterweight, whichever is heavier, to the outside of the curved track. This will prevent the tapered travel wheels from climbing the rail and derailing the crane. Have the signal person flag traffic at street crossings. Sound the horn when approaching intersections or blind corners and use warning bells while backing up. When traveling without loads, set the boom to approximately 45 degrees.



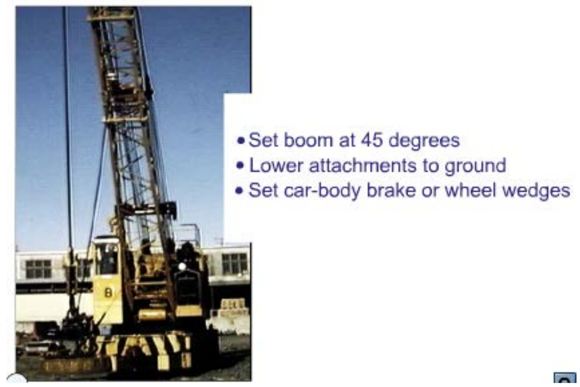
## MOVING RAILCARS WITH A LOCOMOTIVE CRANE

If you need to move rail cars using a locomotive crane use caution when coupling or disconnecting cars. The crane crew shall make sure that no one is working in, on, or under the car, and that nothing will prevent its safe movement. Crews shall uncouple cars only when brakes are set and wheels are properly chocked. Limit the number of cars moved at one time, loaded or unloaded, to the number recommended by the crane manufacturer or by local policy. Locomotive cranes are not usually designed to charge the braking systems of additional cars or to move several cars at a time.



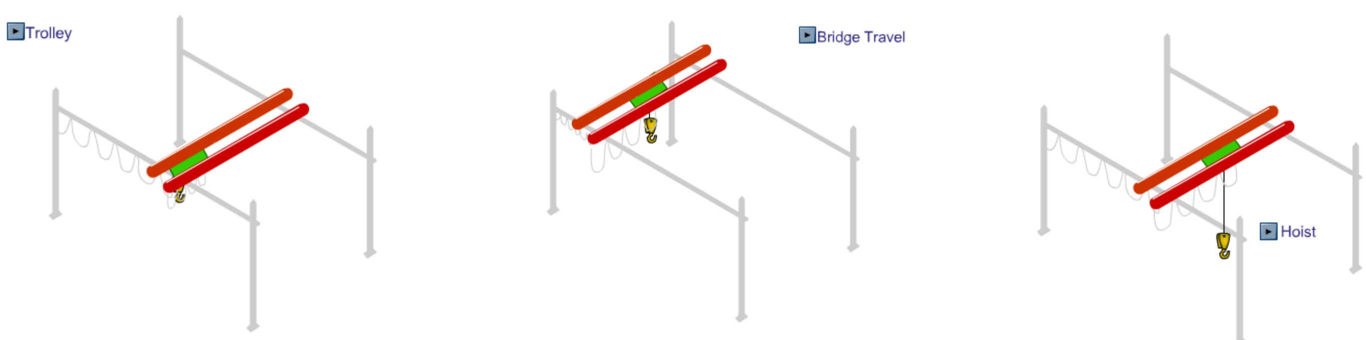

## SECURING LOCOMOTIVE CRANES

When securing locomotive cranes, set the boom at about a 45 degree angle. If equipped with a magnet, clam-shell, or other lifting attachment, lower it to the ground. Set the car-body brake or place wheel wedges against the inner set of travel wheels.

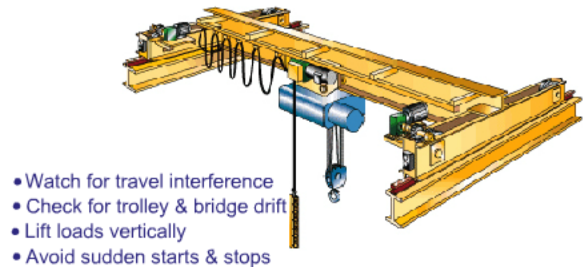



## OPERATING OET AND GANTRY CRANES 1

The bridge travel function is used to travel the crane in the selected direction along the length of the runway rails. This allows the operator to move the entire crane along its supporting rail structure, in the selected direction. The trolley function is used to move the hoisting machinery in the selected direction along the trolley rails. The hoist function is used to raise and lower the hooks.



## OPERATING OET AND GANTRY CRANES 2




Overhead electric traveling cranes are generally operated indoors so congestion is often an issue. Watch for changes in the work area that may cause interference. Storage racks with material stacked too high are a common problem. Operators should always check for trolley and bridge drift before operating the crane. Lift loads vertically. Side pulls can cause uneven or overlapped spooling of the hoist wire and may cause the wire rope to be cut or severely damaged. Avoid sudden starts and stops with the bridge. This can result in skidding and uneven wear on the wheels. A sudden start with a heavy load on one end of the bridge may cause a crane to skew. Skewing means that the bridge and trucks are out of alignment with the rails, often resulting in wheel chatter from flange contact with the sides of the rail head.

## OPERATING OET AND GANTRY CRANES 3

Always board cab-operated cranes at designated places. Access the crane cab or bridge walkway using fixed ladders, stairs, or platforms. Remain aware of other cranes working on the same rail system. For gantry cranes, watch travel truck clearances. For cab-operated gantry cranes, this may require additional personnel to ensure a clear travel path. Use radio controls according to the manufacturer's instruction. Turn off power to the radio controller and properly store when finished operating.

## SECURING OET AND GANTRY CRANES

Move cab-operated cranes to a boarding platform or ladder. Never attempt to walk the rails to enter or exit an OET crane. Secure main power switch, usually located on the bridge, for cab-operated cranes only. When necessary for OET or gantry cranes located out of doors, secure the crane against movement by the wind. Chock the wheels as necessary for travel trucks.

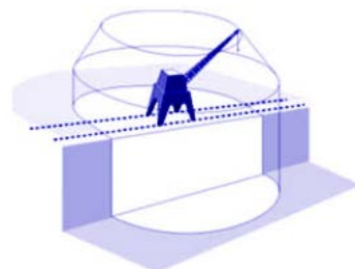
# NOTES

## CRANE AND RIGGING GEAR ACCIDENTS

### ACCIDENT CATEGORIES

There are two general categories of weight handling accidents: Crane Accidents and Rigging Gear Accidents. Crane Accidents are those that occur during operation of category 1, 2, 3, or 4 cranes. Rigging Gear Accidents are those that occur when gear covered by NAVFAC P-307 section 14 is used by itself in a weight handling operation, i.e., without a crane. Or, when covered gear is used with multi-purpose machines, material handling equipment (forklifts), and with equipment covered by NAVFAC P-300 in a weight handling operation.

### CRANE ENVELOPE

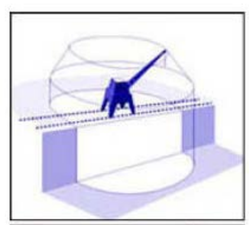


In order to define a crane accident, you must first understand the crane operating envelope. The operating envelope includes the crane, the operator, the riggers, and the crane walkers, other personnel, the rigging gear between the hook and the load, the load itself, the supporting structures, such as the rails or the ground, and the lift procedure.

### RIGGING GEAR OPERATING ENVELOPE

The rigging gear operating envelope contains the rigging gear and miscellaneous equipment covered by NAVFAC P-307 section 14, the user of the gear, the load itself, other personnel involved in the operation, the structure supporting the gear, the load rigging path, and the rigging procedure.

### CRANE ACCIDENT DEFINITION



A crane accident occurs when any of the elements in the operating envelope fail to perform correctly during operations, including operations during maintenance or testing, resulting in the following: personnel injury or death, material or equipment damage, dropped load, derailment, two-blocking, overload or collision.

## RIGGING GEAR ACCIDENT DEFINITION

Rigging gear accidents occur when any of the elements in the operating envelope fails to perform correctly during weight handling operations resulting in the following: personnel injury or death, material or equipment damage, dropped load, two blocking, or overload.

## ACCIDENT EXAMPLES

Some common examples of accidents are: dropped loads, injuries from a shifting load, failure of rigging gear resulting in a dropped load, overloads, and improperly secured loads falling from pallets.

## ACCIDENT EXCEPTION

Component failure such as motor burnout, gear tooth breakage, bearing failure, etc. is not considered an accident just because damage to equipment occurred, unless the component failure causes other damage such as a dropped boom or dropped load.

## ACCIDENT CAUSES

In most cases, crane accidents are due to inattention to the task, poor judgment, team members having too much confidence in their abilities or operating the crane too fast.

**Primary Accident Causes**

*In most cases, crane accidents result from personnel error and can be avoided.*

In most cases, crane accidents are due to:

- Inattention to the task
- Poor judgment
- Overconfidence
- Excessive speed

## Operator Responsibilities

The operator can play a significant role in eliminating human error and accidents. Drugs and alcohol can affect a person's capability to think, reason, or react in normal situations and can certainly lead to serious accidents. Operators must always consult their physicians regarding effects of prescription drugs before operating equipment, and recognize that medications often affect people differently. An operator is responsible for evaluating his or her physical and emotional fitness.

## Accident Response/Actions

If a crane accident occurs, personnel must take the following actions:


Stop operations as soon as possible, however don't stop at the expense of safety.

In some circumstances, for example, if a crane is involved in a collision as a load is being lowered, the operator should first land the load, then, follow the accident response procedure. Don't try to correct the problem unless life or limb is in danger. Call, or have someone call 911 if an injury occurs. Secure the crane. Secure power as required. If danger exists to the crane or personnel, place the crane and load in a safe position. Notify supervision as soon as safely possible. Ensure that the accident scene is preserved to aid the investigation.

## Contractor Accident Response/Actions

The contractor shall notify the contracting officer as soon as practical but no later than four hours after any WHE accident. Secure the accident site and protect evidence until released by the contracting officer. Conduct an accident investigation to establish the root cause(s) of any WHE accident. Crane operations shall not proceed until cause is determined and corrective actions have been implemented to the satisfaction of the contracting officer. Contractors shall provide to the contracting officer, within thirty days of any accident, a Crane and Rigging Gear Accident Report using the form provided in NAVFAC P-307 Section 12 consisting of a summary of circumstances, an explanation of cause or causes, photographs (if available), and corrective actions taken.

### CONTRACTING OFFICER ACCIDENT RESPONSE/ACTIONS

The contracting officer shall notify the host activity of any WHE accident upon notification by the contractor and provide the Navy Crane Center and the host activity a copy of every accident report, regardless of severity, upon receipt from the contractor. The contracting officer shall notify the Navy Crane Center of any accident involving a fatality, in-patient hospitalization, overturned crane, collapsed boom, or any other major damage to the crane, load, or adjacent property as soon as possible, preferably within twenty four hours of notification by the contractor. When the contracting officer is not in the local area, the contracting officer shall designate a local representative to ensure compliance with the above noted requirements. The above requirements are in addition to those promulgated by OPNAVINST 5100.23 and related local instructions.

# NOTES

Naval Facilities Engineering Command
NAVY CRANE CENTER

# CRANE RIGGER COURSE EVALUATION SHEET

Student Name: ______________________________ Command: ____________________

Course Title: ________________________________ Date: ______________________

Instructor: ________________________________________________________________

**Directions:** To assist in evaluating the effectiveness of this course, we would like your reaction to this class. Do not rate questions you consider not applicable.

| **Please rate the following items:** | Excellent | Very Good | Good | Fair | Poor |
|---|---|---|---|---|---|
| Content of the course met your needs and expectations. | | | | | |
| Content was well organized. | | | | | |
| Materials/handouts were useful. | | | | | |
| Exercises/skill practices were helpful. | | | | | |
| Training aids (slides, videos, etc.) were used effectively. | | | | | |
| Instructor presented the material in a manner, which was easy to understand. | | | | | |
| Instructor was knowledgeable and comfortable with the material. | | | | | |
| Instructor handled questions effectively. | | | | | |
| Instructor covered all topics completely. | | | | | |
| Probability that you will use ideas from the course in your work. | | | | | |
| Your opinion of the course. | | | | | |
| Your overall opinion of the training facilities. | | | | | |

What were the key strengths of the training? How could the training be improved? Other comments?

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

________________________________________________________________________

List other training topics in which you are interested: ______________________________

________________________________________________________________________

________________________________________________________________________

**Note:** If you would like a staff member to follow up and discuss this training, please provide your phone number________________________________________________________

*Complete form and return to instructor.*